UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

FRUIT BEVERAGE INVESTIGATIONS

BY

W. V. CRUESS AND J. H. IRISH

BULLETIN No. 359
April, 1923

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA
1923

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W. V. CRUESS AND J. H. IRISH

CONTENTS

In 1921 the California State Legislature appropriated a special fund for the study of new and improved methods of utilizing California fruits. The investigations reported in this publication form an important part of the studies made possible by this appropriation.

Extent of the Beverage Industry.—According to the annual report of the Commissioner of Internal Revenue, the value of all soft drinks, exclusive of mineral waters, consumed in the United States and possessions for the year ending June 30, 1921, was $618,394,565.90. The value of bottled beverages, other than unfermented grape juice, ginger ale and mineral waters, was $242,962,794.70. At an average of five cents per bottle, this would represent nearly 5,000,000,000 bottles, or approximately forty-five bottles per capita. Unfermented cider is not listed in the report. This represents an increase of approximately 66 per cent over the consumption estimated by the United States Department of Agriculture for 1918.*

Of the totals given above, California produces approximately 3.4 per cent of the unfermented grape juice and natural mineral waters, 2.5 per cent of the cereal beverages, and 5.1 per cent of the remaining soft drinks.

The commissioner's report shows that, of the beverages consumed in America, only a very small proportion is made from fruits. Our investigations have demonstrated that it is possible to prepare from fruits, at a moderate cost, beverages superior in quality to the imitation fruit beverages now sold in such large quantities. California is in a particularly favorable position to produce such fruit beverages.

Types of Unfermented Bottled Beverages.—The principal classes of bottled beverages are (1) cereal beverages, prepared usually from barley malt and hops; (2) imitation fruit beverages, which are often given fanciful names such as "crush," "squeeze," "squash," preceded by the name of a fruit; (3) mineral waters, natural and artificial, and (4) fruit beverages, still and carbonated.

There are two kinds of imitation fruit beverages. The cheaper type is prepared entirely from sugar, water, and citric or tartaric acid with artificial color and flavor. No fruit juice is used. The other kind is prepared in a similar way but with the addition of a small amount of fruit juice or syrup, or of fruit distillate. Most of the so-called "true fruit" syrups and flavors are of this second type. The name "true fruit" is misleading, because much of the flavor and color of the product is derived from coal tar products and sources other than fruits.

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* Weekly News Letter U. S. D. A., May 14, 1919, estimates consumption at 3,000,000,000 bottles per year.

Most of the so-called "strawberry," "raspberry," "lemon," and other bottled soda waters contain no fruit juice or other fruit product. In many cases these imitations are not labeled prominently as imitations.

Of the carbonated fruit beverages on the market, carbonated apple juice is the most important and most popular. Carbonated loganberry and pineapple beverages prepared from the juice of the fruits, sugar, and carbonated water are also obtainable, but are produced on a less extensive scale. Attempts to produce bottled carbonated citrus fruit beverages have not been successful commercially, because of the tendency for these products to deteriorate rapidly in flavor and color after bottling. Most of the so-called citrus beverages sold in bottles are prepared wholly or in part with artificial color, flavor, and other ingredients which are not fruit juices.

The most important non-carbonated bottled fruit juices are made from grapes, apples, pineapples, and loganberries.

PREPARATION OF SYRUPS FOR BOTTLING

Syrups are used in soda fountains and by soda water bottlers in preference to fruit juices as the basis for carbonated beverages. An important part of our investigations, therefore, has been the study of methods of preparing pure fruit syrups for this purpose.

Raw Materials.—There are available in California for the preparation of fruit juices and syrups large quantities of cull apples, oranges, lemons, grape fruit, table grapes, berries, and pomegranates. This cull fruit, although generally unsuitable for fresh shipment, canning, or drying, is often of equal value with the better grades of fruit for the making of syrups and juice.

The Yellow Newtown, Gravenstein, and Bell Flower, are the principal varieties of apples available for juice in central California, and the Rome Beauty, Winesap, and Delicious, in southern California. All these varieties are satisfactory for cider, although the Yellow Newtown, Winesap, and Rome Beauty are best for this purpose on account of their more pronounced flavor and higher acidity.

There is estimated to be available in this state enough cull apples suitable for juice to yield at least one million gallons of cider a year.

In normal years probably not less than five per cent of the orange crop is discarded in the orchards and packing houses as culls. In years of heavy frost damage the percentage of cull fruit is much higher. Cull unfrosted oranges are equal to the packed fruit for juice purposes. Frosted oranges are also satisfactory if utilized before

the fruit has undergone severe drying and change in flavor after freezing. There are probably enough cull oranges available to yield two million to five million gallons of juice a year.

Lemons unsuitable for fresh shipment are now utilized to a large extent for the manufacture of citric acid and lemon oil. Most of this fruit is also satisfactory for the preparation of lemon juice and syrup.

Pomelos (grape fruit) are not grown very extensively in California and the amount available for by-products is small in comparison with that of oranges and lemons.

Second crop Muscat grapes usually ripen so late that they cannot be made into raisins by sun drying, and are often not harvested. They are excellent for the making of juice and syrup.

The tonnage of second crop Muscat grapes varies greatly from year to year, but an average of at least twenty thousand tons is available yearly. This amount would yield about three million gallons of juice.

Cull table grapes yield juices lacking in distinctive flavor, but their juices can be used if blended with more highly flavored juices.

Muscat raisins of the smaller sizes are difficult to market. The seeds and waste wash-water from the seeding of Muscat raisins contain about twenty per cent of sugar. All of these materials have been found to yield syrups suitable for use as a base for carbonated beverages.

The production of wine grapes of all varieties in California is approximately five hundred thousand tons a year. Much of this is available for the preparation of syrups and unfermented beverages.

Strawberries and other berries, too small or too ripe for fresh shipment or for preserving, may be utilized with advantage as raw materials for preparing soda fountain and bottling syrups. Strawberries, loganberries, and blackberries (Lawton, Himalaya, and Mammoth varieties) are available in sufficient quantities for the commercial production of syrups. Raspberries are not produced in sufficient volume and are too high priced in California for this purpose.

Pomegranates are being planted extensively in the San Joaquin Valley. A large proportion of the fruit splits on the tree and is on this account unsuitable for fresh shipment. The split fruit, is, however, equal to the whole fruit for juice making. The juice is of deep red color and pleasing flavor and blends well with other juices.

Pineapple beverages are popular. Pineapple juice and syrup are now produced on a commercial scale in the Hawaiian Islands and are available at moderate prices for the use of bottlers and soda-fountains.

Maturity of the Fruit.—In our experiments the effect of the maturity of the fruit on the quality of the product was studied. As a result of these investigations the following recommendations are made.

Apples for juice should be crisp and firm and not mealy. When thoroughly ripe they often yield juice deficient in flavor and acidity, and difficult to filter.

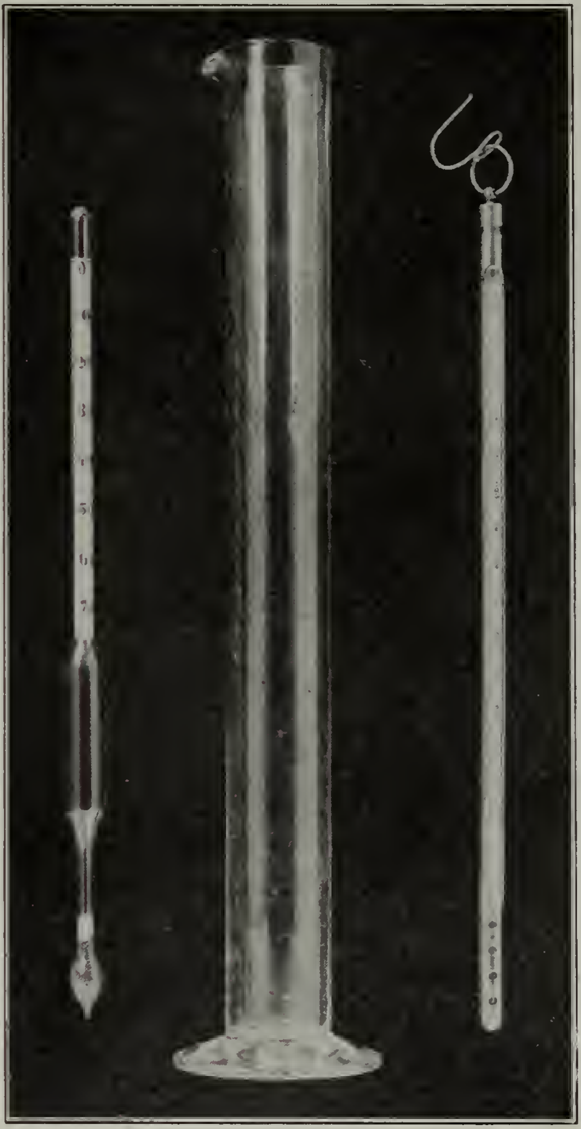

Fig. 1.—Balling hydrometer, hydrometer cylinder, and thermometer.

Oranges should be fully matured because when unripe they produce a bitter juice. Often oranges ripe enough to conform to the 8:1 Balling-acid test yield a juice which rapidly becomes bitter after expression.

Red wine grapes for juice should be harvested when they test 18–21° Balling.

First crop Muscat grapes are best at approximately 22° Balling. Grapes grown in California tend to become too sweet and too low in acidity for use as juice. If they are to be used in the preparation

of syrup they should be allowed to attain 22–24° Balling. The syrup is used in preparing carbonated beverages and any slight deficiency in natural acidity is made up by the 'sharpness' of the carbon dioxide. Second crop Muscat grapes are more tart and lower in sugar content than first crop grapes. They should be allowed to become as rich in sugar before harvesting as the season will permit.

Berries should be 'soft ripe' when used for juice or syrup, in order to obtain the maximum flavor, color, and sweetness. This is particularly true of loganberries.

We have found that pomegranates also should be fully matured in order that the juice will be of deep red color and of the best flavor.

Harvesting and Transportation of the Fruit.—Too little care often is taken in the harvesting and transportation of fruit to be used for juice or syrup. Firm fruits may be harvested in lug boxes. Berries must be placed in shallow drawers or boxes in order to avoid crushing and consequent loss of juice.

Fruit boxes and berry drawers must be clean and as free as possible from decayed fruit, mold, and soured juice. The boxes should be washed and scrubbed frequently, particularly if the fruit tends to break down during shipment.

Soft fruits such as berries and many grapes should be transported to the factory and converted into juice or syrup with as little delay as possible. Twenty-four hours should be the maximum time between harvesting and crushing of soft fruits.

Firm fruits such as apples and citrus fruits, if sound and harvested carefully, may often be held in storage for a considerable period before crushing. Cold storage apples and oranges are very generally used in large cities in cider stands where fresh cider and orange juice are sold.

Sorting and Washing.—In our investigations we have found it necessary to sort carefully practically all varieties of fruits before crushing. Cull oranges, lemons, and apples require vigorous washing to remove sooty deposits, dust, etc. The brush and spray washers used in washing citrus fruits for fresh shipment would be suitable for washing apples, citrus fruits, and pomegranates to be used for juices.

Grapes can be washed satisfactorily by vigorous sprays of water. Usually, sorting is not necessary if the grapes are crushed within twenty-four hours after picking.

Berries must be very carefully sorted. Gentle sprays of water should be used to remove dust.

Crushing.—It was found that citrus fruits could be pressed most satisfactorily if merely cut in halves or quarters; crushing was not necessary.

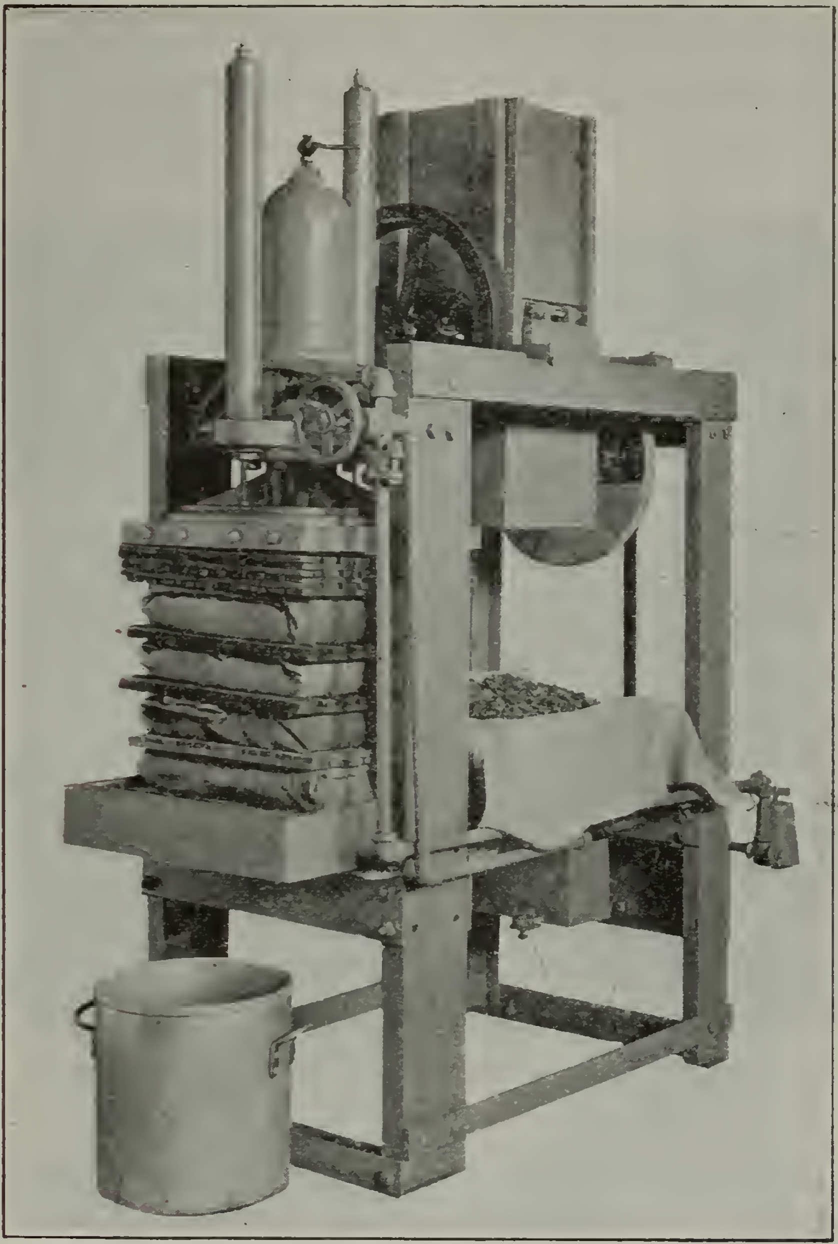

Fig. 2.—Fruit crusher and hydraulic press in the Fruit Products Laboratory.

In crushing grapes at the University Farm a hand power crusher consisting of two revolving fluted rolls was used. At Berkeley the apple grater shown in figure 2 was used. White grapes were crushed but not stemmed. The presence of the stems facilitated pressing. Red grapes were crushed and stemmed, in our experiments at the University Farm at Davis. Since these grapes were heated before pressing it was found desirable to remove the stems before heating, in order to avoid extraction of an excessive amount of tannin and 'stem' flavor. Heating also softened the crushed berries and thereby greatly facilitated extraction of the juice by pressing.

Apples were grated before pressing by means of a power driven apple grater of a standard design shown in figure 2. This grater or crusher consists of a steel cylinder equipped with short knives, which revolves toward a fluted, curved piece of cast steel which is parallel to the cylinder, and adjustable. The fruit may be grated to any degree of fineness by adjustment of the distance between the revolving cylinder and the curved plate.

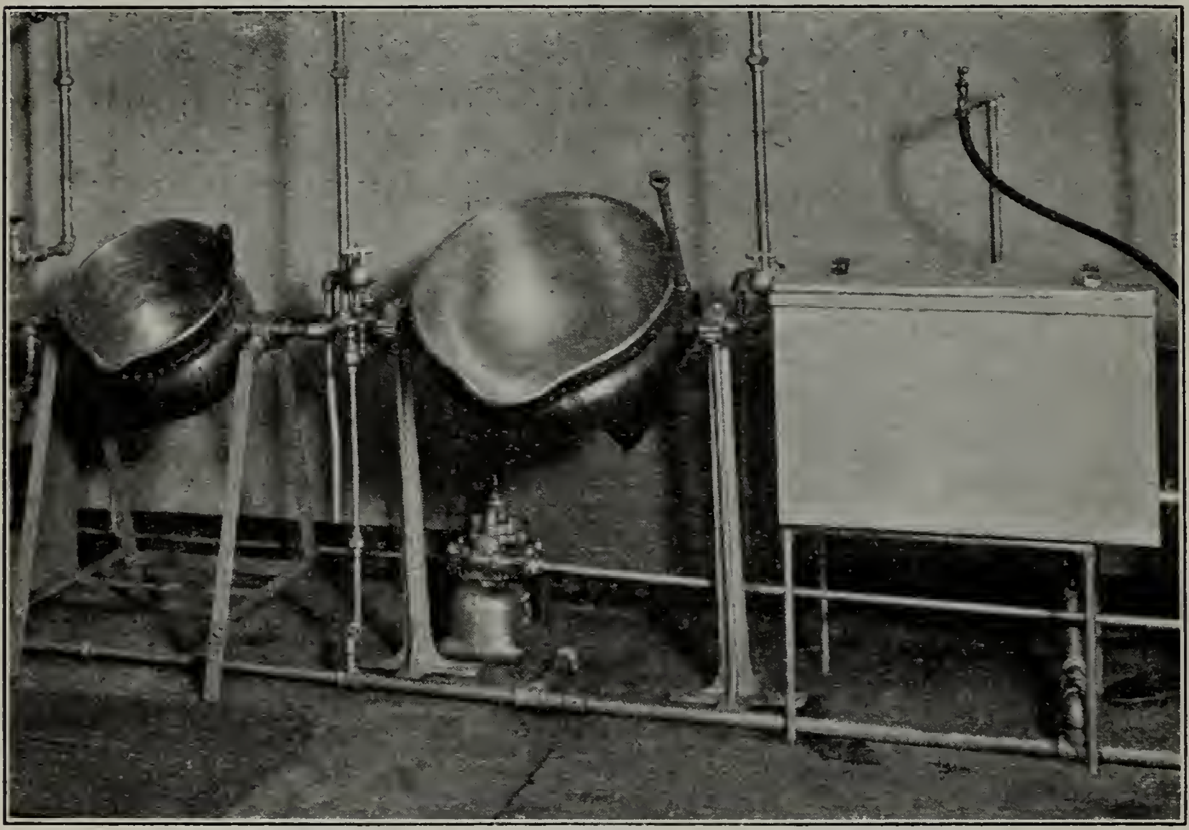

Fig. 3.—Steam jacketed kettles and pasteurizer in the Fruit Products Laboratory.

Berries were crushed in a tin lined Enterprise combination screw crusher and press. (See illustration in circular 220.) Contact with iron injured the color of the juice and for this reason the apple grater was not used for berries.

Crushed pomegranates yielded a very astringent juice not suitable for beverage purposes. The halved fruit was difficult to press. The best results were obtained by pressing the whole fruit without previous treatment other than sorting and washing.

Heating.—Berries and red grapes were heated before pressing in order to extract the red color and to give an increased yield of juice.

In the experiments at the University Farm the crushed red grapes were placed in the basket of a large hand press and pressed lightly. The pressed grapes were then transferred to a small wooden vat. The

juice was heated to 160–170° F. by passing it through a water jacketed aluminum coil. The heated juice was then mixed with the crushed grapes giving a final temperature of about 130° F. The mixture was allowed to stand about eight hours before pressing. Temperatures above 140° F. caused the extraction of an excess of tannin and of disagreeable flavors from the seeds.

Fig. 4.—Basket press, hand power size.

At Berkeley the crushed grapes were heated to 160° F. in a steam jacketed, silver-lined copper jelly kettle and pressed at once. The juice obtained was somewhat harsher in flavor than the juice prepared by extraction of the color at 130° F. Nevertheless, the juice from grapes heated to 160° F. was of very satisfactory flavor and of excellent color. Petite Sirah, Barbera, and Alicante Bouschet gave juices of deeper color and better flavor than that obtained from Zinfandel.

Berries were heated to 140° F. and pressed at once. When heated too long, a large amount of pectin was extracted from loganberries and blackberries. The presence of pectin caused jelling of some of these syrups.

Aluminum was found to affect the color and flavor of the juices less than copper or tin. Glass lined equipment (heavily enameled steel) was found to affect the flavor and color of the juices less than any of the metals used in our experiments. These included iron, nickel, silver, zinc (galvanized iron), aluminum, copper, and tin. Zinc and iron dissolved rapidly in the heated juice, and after a few minutes' contact the juice was undrinkable.

Pressing.—Two types of presses were used in our experiments. One of these, the basket style of grape press, shown in figure 4, was found to be very satisfactory for pressing of grapes, halved citrus fruits, and whole pomegranates. It was found desirable to line the inside of the basket with burlap, straw, or heavy press cloth in order to reduce the amount of pulp expressed with the juice.

Berries and apples were pressed through coarsely woven press cloths placed between wooden racks or gratings in a rack and cloth press operated by hydraulic pressure. (See figure 2.) Berries were placed in a piece of closely woven cloth, such as canvas, inside of the coarsely woven press cloth. This prevented the berry pulp from squeezing out through the press cloth into the juice, thus facilitating filteration of the juice as well as the removal of the pomace from the press cloth.

The basket press was not suitable for these fruits because it did not exert sufficient pressure. Higher yields of juice, and clearer juice, from grapes, citrus fruits, and pomegranates were obtained by use of the rack and cloth press than from the basket press, although the labor cost of operation with the rack and cloth press was greater than with the basket press.

In commercial practice continuous screw presses have been used in two or three factories for pressing unfermented grapes, but have proved unsatisfactory because the fruit is ground to a "puree," and the resulting juice contains an excessive amount of pulp, which renders filtration extremely difficult.

For general purposes the rack and cloth (fig. 2) press was found the most satisfactory.

Clearing the Juice.—Citrus fruit juices were found to be most pleasing in flavor and appearance when used without removal of the pulp by filteration or other means. The presence of unbroken juice sacs in orange juice or syrups improved its appearance.

Other fruit syrups and beverages were most attractive when perfectly clear. Several methods of clearing the juices were studied. These included filtration, fining, and centrifugal clarification.

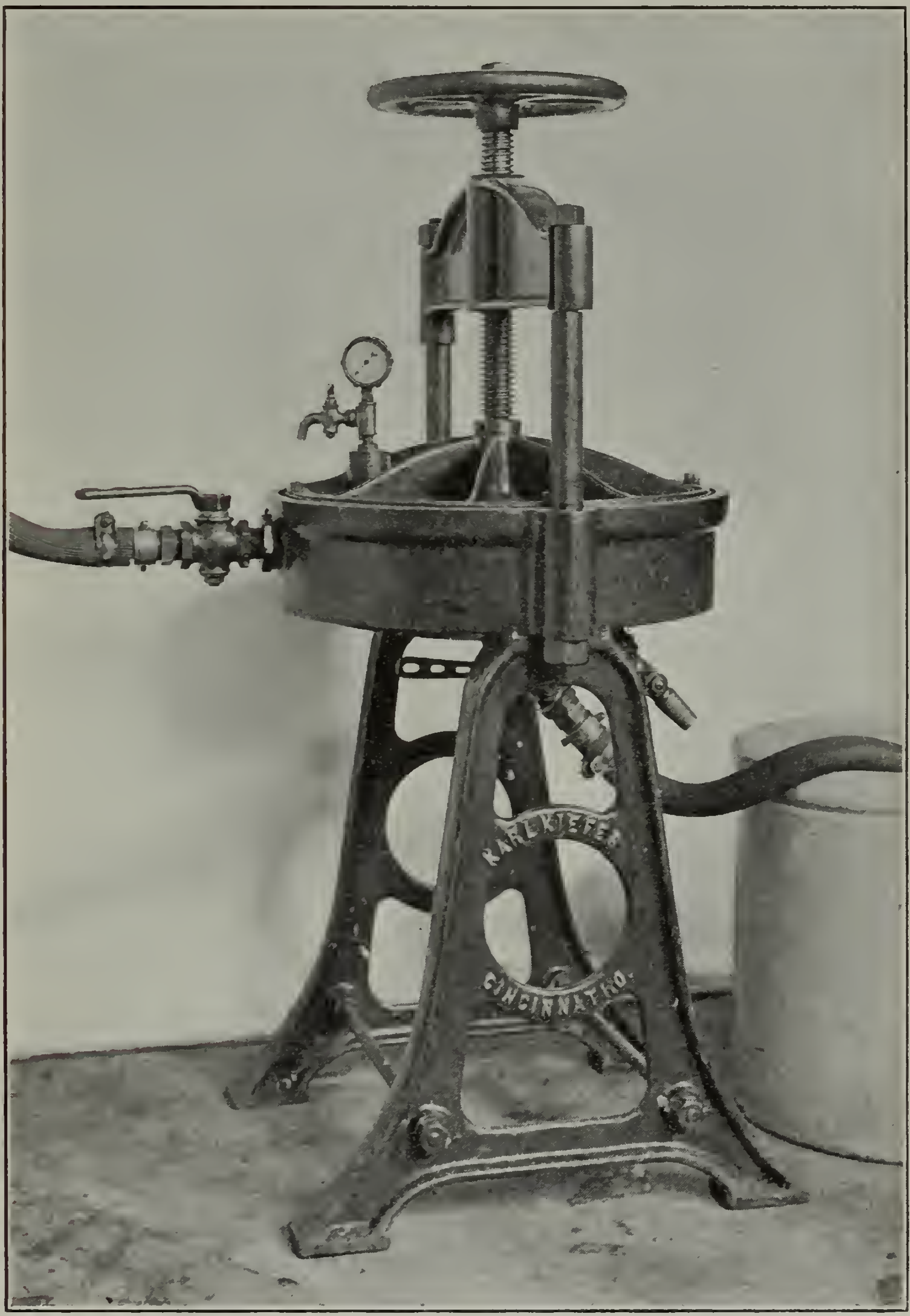

Fig. 5.—Small industrial size pulp filter (Karl Kieffer).

Filtration was found to be the most practical method for most juices. The pulp filter shown in figure 5 was used for filtration of most of the large lots of juice prepared at Berkeley. This filter consists of two discs of cotton fiber, each about one inch thick and separated by a silvered screen disc. The two pulp discs act as inde-

pendent filters. The discs are formed by pressing washed cotton fiber tightly into forms designed for the purpose. The discs are enclosed in a silver lined, circular chamber closed with a large rubber gasket and silver lined plate. The juices were, in most cases, roughly filtered through coarse felt before filtration through pulp (see figure 6).

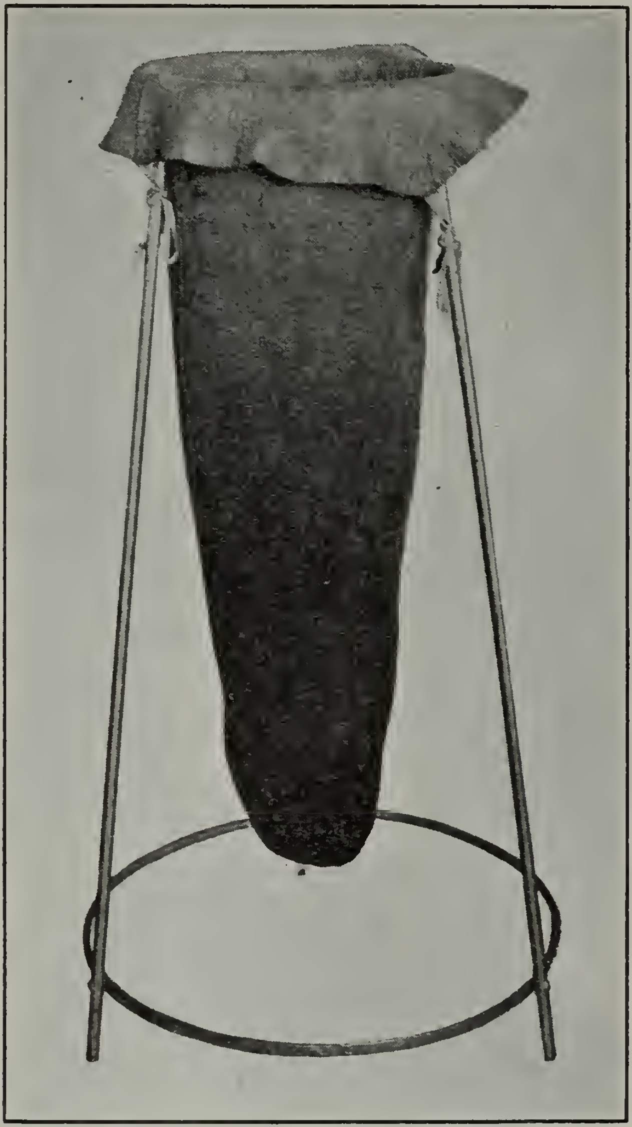

Fig. 6.—Felt jelly bag for preliminary filteration.

The juice was placed in a tin lined cylinder and forced through the pulp under air pressure. One filtration through lightly pressed and one through tightly pressed pulp rendered most juices brilliantly clear and did not impair their flavor. The rate of filtration of Muscat juice was 100 gallons an hour and of cider 120 gallons.

A small pulp filter designed for filtering fruit juices on the home scale was also successfully used. This filter is very simple in design and operation. Suction is obtained by a small water jet pump, which may be attached to any water faucet. The rate of filtration for most

fruit juices was found to be about 10 gallons an hour. The filter is shown in figure 7.

At the University Farm an asbestos filter was used. This consisted of a silver lined cylinder inside of which was placed a fine mesh silver screen cylinder. Short fiber asbestos was mixed with the juice and the mixture poured into the filter, where it formed a filtering layer of

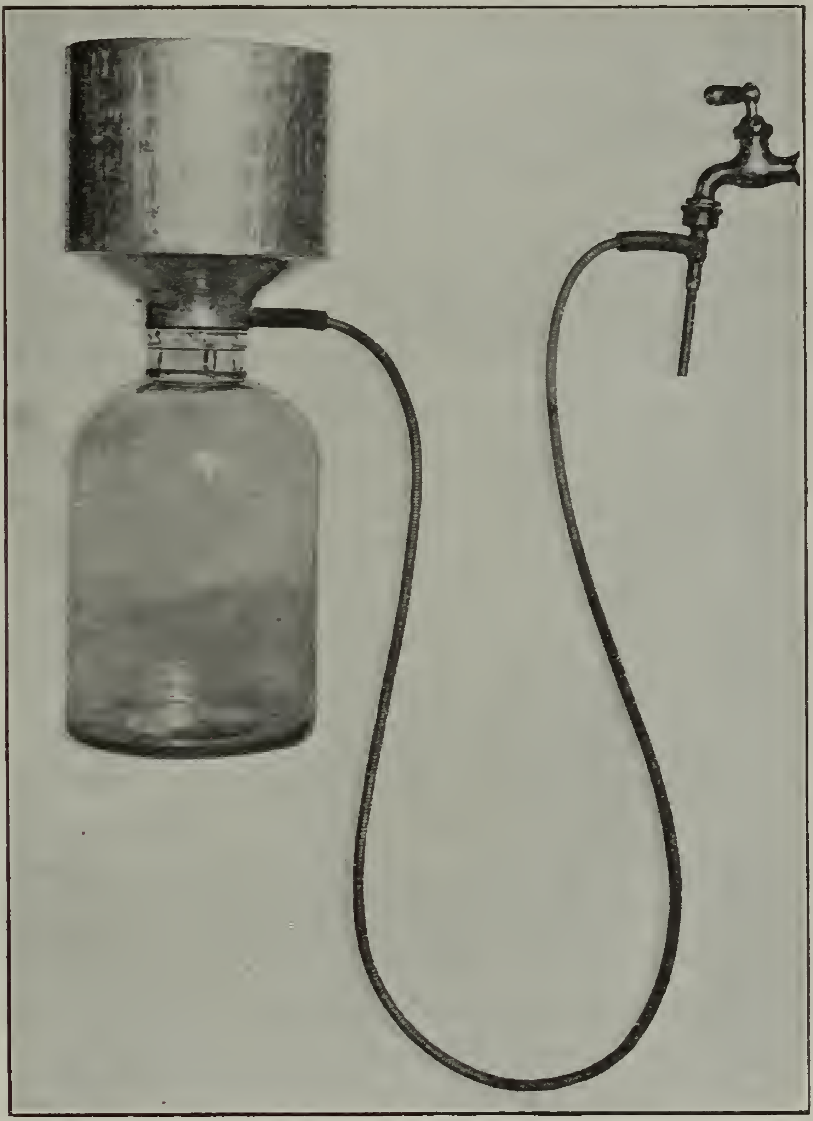

Fig. 7.—''Cellulo'' pulp filter, suitable for small scale filtration.

asbestos about one-half inch thick on the screen. The juice was forced through the filter by gravity pressure obtained by connecting the filter inlet to a reservoir of the juice placed about ten feet above the filter. The filtration was slow, but the filtered juice was clear. This filter was not so satisfactory as the pulp filters described above and shown in figures 5 and 7.

A small plate and frame filter press was used in several experiments made on a small scale. This filter press consisted of twenty pieces of canvas or filter cloth placed between enamel coated steel

plates of the type shown in figure 8. The plates and cloths were about six inches square and the total filtering surface about ten square feet. It was found necessary to coat the surface of the filter cloths with infusorial earth, or to mix this material with the juice in order to hasten filtration and to obtain a clear filtrate. The infusorial earth used in our experiments was a finely pulverized, 'fluffy' product sold under the name of Filter-Cel. In our first experiments the unheated earth was used. This imparted an ''earthy' taste to the filtrate. This flavor, however, was in later experiments, removed from the earth by washing with cold water. Washing was accomplished by mixing the earth with water, passing the mixture into the filter to coat the cloths and forcing water through the filter until the filtrate no longer tasted of the earth. A special grade of the Filter-Cel, baked at the factory to remove the earthy taste, was found satisfactory for mixing directly with the juice. About one-half of one per cent to one per cent of the earth by weight was used.

In commercial juice factories large plate and frame presses have been used successfully. The metal parts of the filter must be coated with tin or other material to prevent contact of the juice with iron.

Clarifying by adding fining materials, such as casein, egg albumin, Spanish clay, etc., was not successful, except with red grape juice. Filtration was found to be more satisfactory.

High speed centrifugal clarifiers were tested. They are similar to cream separators in design. The bowl of the separator operates at fifteen thousand to thirty thousand R.P.M. It was found possible to remove coarse particles of pulp, but not to obtain a brilliantly clear liquid. Centrifugal clarifiers would be useful for partial clearing before filtration.

It was found desirable to heat most fruit juices to about 150–165° F. and to allow them to cool before filtration. This treatment caused coagulation of proteins, which otherwise tended to precipitate and cause cloudiness of the juice or syrup during final pasteurization in the bottle.

Berries were heated to 140° F. before pressing. This heating accomplished the same results as heating other juices after pressing.

Apple juice was an exception to the above rule. It was filtered without previous heating and in most cases did not become cloudy when pasteurized after filtration.

Syrups by Addition of Sugar.—Syrups were prepared from various juices by three methods; namely, addition of sugar, concentration in vacuo, and concentration by freezing.

The most satisfactory syrups for bottling purposes were obtained when cane sugar was added to berry, lemon, grape fruit, and pomegranate juices. These juices also required the addition of sugar to counterbalance their high acidity before they were satisfactory for beverage purposes. The sugar also tended to retain the fresh fruit flavor and color. The unsweetened juices deteriorated rapidly in both color and flavor after pasteurization.

Berry juices were sweetened to various degrees Balling, but 50° Balling was found best for all except loganberry. Addition of more sugar caused the juice to jell and when less was used the flavor and color were not so well retained. This corresponds to slightly less than equal sugar by weight. Loganberry juice made up to 50° Balling jellied when pasteurized. The degree of sweetness for loganberry juice therefore, should not exceed 45° Balling. The sugar was added after filtration, because the addition of sugar greatly increased the viscosity of the juice and impeded filtration.

The sugar was dissolved by stirring in the cold juice or by suspending it in a cheese cloth bag at the surface. The syrup thus prepared was strained through cheese cloth in order to remove any lint present in the sugar or on the bag.

Pomegranate juice was sweetened by the addition of sugar to 35° Balling. At higher concentrations, the beverage obtained when the proper proportion of carbonated water was added was weak, both in color and flavor.

Citrus fruit syrups prepared by the addition of sugar were brought to 65° Balling. At lower concentrations the flavor of the citrus fruit syrups deteriorated rapidly in storage. The most satisfactory syrup was made by blending approximately three parts of orange juice with one part of lemon juice and bringing to 65° Balling by the addition of sugar.

Concentration in Vacuo.—When fruit juice is concentrated in an open kettle a syrup of brown color and molasses-like flavor is obtained. Such syrup is totally unsuited for use in the preparation of carbonated beverages. Darkening of the color and development of the molasses flavor are caused by the high temperature of the boiling syrup at atmospheric pressure.

In the open at sea level water boils at 212° F. and heavy syrups at 220° F., or above. If water or fruit juice is placed under reduced pressure, i.e., in a vacuum, the boiling point is lowered in proportion to the degree of vacuum.

Barometric pressure of the atmosphere is usually expressed in inches of mercury, representing the height in inches to which a mercury column will be raised by pressure of the atmosphere. Vacuum is expressed in the same terms as atmospheric pressure. Vacuum may be expressed as "inches of pressure," or as "inches of vacuum." Thus, "2 inches positive pressure," is approximately the same as 27.8 "inches vacuum." In commercial practice "inches vacuum" is the more common term.

Under a perfect vacuum, approximately 29.9 inches vacuum, the boiling point of water is below the freezing point, 32° F. Water boils at 32° F. at 29.82 inches vacuum. At 28 inches the boiling point is approximately 100° F. At a high vacuum each inch increase causes a greater drop in temperature than at a low vacuum. Thus, increasing the vacuum from 28 to 29 inches decreases the boiling point of water about 25° F., whereas increasing the vacuum from 26 to 27 inches decreases the boiling point only about 10° F. The relation between the boiling point and vacuum in inches of mercury is given in table.

TABLE 1

RELATION BETWEEN THE BOILING POINT OF WATER AND VACUUM IN INCHES

Vacuum, in Inches, Mercury	Boiling Point, F°	Vacuum, in Inches, Mercury	Boiling Point, F°
29.8191	32	27.4040	110
29.7516	40	27.0050	115
29.6365	50	27.5530	120
29.5631	55	26.0400	125
29.4770	60	25.4800	130
29.3760	65	24.8300	135
29.4590	70	24.1100	140
29.1250	75	22.4200	150
28.9680	80	20.3200	160
28.7880	85	17.7700	170
28.5800	90	14.6700	180
28.3410	95	10.9300	190
28.0700	100	6.4700	200
27.7590	105	1.1600	210
		0.0000	212

The equipment used commercially for the concentration of liquids under vacuum consists of a closed vessel, the vacuum pan, connected to a vacuum pump, which exhausts the air from the apparatus. Between the vacuum pan and the vacuum pump is a condenser which

condenses the vapors from the vacuum pan to liquid form. The vacuum pan usually consists of a cylindrical steam jacketed vessel, equipped inside with a steam heated coil, or steam jacketed vertical tubes (callandria).

Vacuum pumps are of two types, wet and dry. The wet vacuum pump is of the cylinder, force pump type and is usually operated by steam. It exhausts not only the air from the vacuum pan, but also the condensed vapors. The wet pump rarely gives a vacuum greater than 27 inches. The dry vacuum pump is so connected that

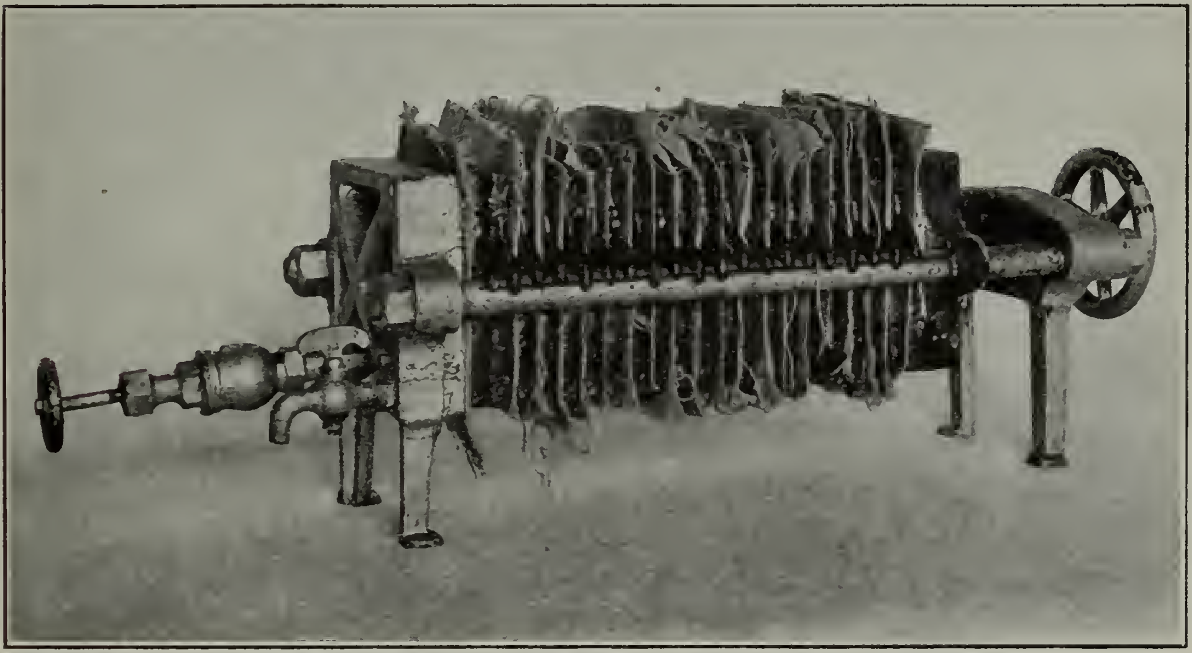

Fig. 8.—Small filter press showing filter cloths and frames in position.

it handles only the air from the pan. In this case the condensed water vapors are taken care of by a "barometric leg," a pipe about 35 feet high dipping beneath water at its lower end. The barometric leg is connected at the top to the condenser and connection to the vacuum pump is made beyond the condenser. By use of the dry vacuum pump 28 to 29 inches of vacuum is readily obtained in commercial practice.

Condensers are of two types, spray or jet, and surface condensers. In the spray or jet condenser the vapors come in contact with a spray or jet of water in an enclosed chamber. In the surface condenser the vapors are condensed in water jacketed coils or other water jacketed device. The spray system is the more generally used because of its simplicity and efficiency.

In our experiments two vacuum pans were used. One of these was a small steam jacketed, silver lined copper pan which permitted the concentration of about five gallons of juice to a charge. The other

pan was constructed of glass lined steel, was steam jacketed, and had a capacity of about ten gallons of juice to a charge. (See fig. 9.)

Both pans were connected to water cooled coil condensers and to a dry rotary vacuum pump capable of producing about 27 inches of vacuum in the pans.

In comparing the two pans with respect to the concentration of various juices, it was found that the glass lined pan caused much less injury to the color and flavor of the concentrate than did the metal pan, when the pans were operated under similar conditions. Grape syrups and apple syrup suitable for the preparation of carbonated beverages were made successfully by vacuum concentration.

Apple syrup concentrated under vacuum was supplied us by a company located in Washington state. The syrup was found fairly satisfactory for use in the preparation of a carbonated beverage.

Orange syrup has been prepared upon a commercial scale by the Exchange Orange Products Company at San Dimas, California, and the syrup has proved very satisfactory in the preparation of carbonated beverages. A glass lined vacuum pan and a very high vacuum were used in concentrating the juice.

The juice from which the syrup was prepared was obtained by pressing the whole fruit. The orange oil expressed with the juice was separated from the juice before concentrating, but was returned to the syrup before the beverage was bottled in order to intensify the flavor.

Orange syrup deteriorated in flavor during storage, but was still suitable for bottling purposes six months after concentration. C. P. Wilson, in charge of investigations on orange syrup at the San Dimas factory, found that a vacuum of at least 28 inches was necessary for the production of syrup of pleasing flavor.

Orange syrup suitable for bottlers' and for fountain use has also been prepared commercially by Gould and Drake of San Francisco, by concentration of the juice under vacuum. It has therefore been shown that grape, apple, and orange syrups for bottlers' use may be successfully prepared commercially by vacuum concentration.

Grape syrups made by concentration under vacuum have retained their flavor and color in glass containers for more than a year. For details of grape syrup manufacture see Bulletin 321 of this station. This publication is out of print but may be consulted in public libraries.

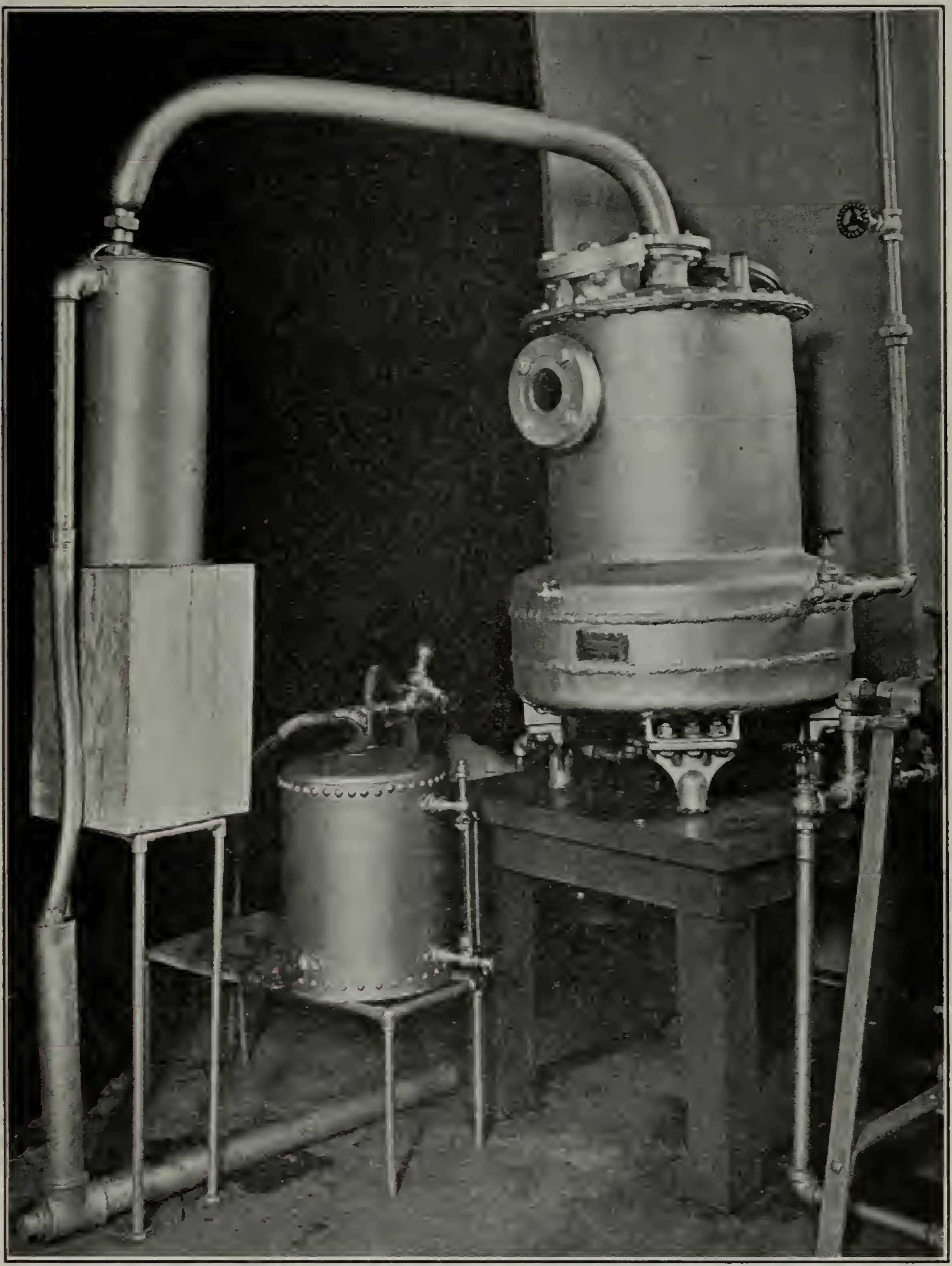

Fig. 9.—Glass lined vacuum pan in the Fruit Products Laboratory.

Condensation of Volatile Flavoring Compounds.—The concentration of any fruit juice by boiling under a vacuum results in considerable loss of flavor and aroma through volatilization of compounds responsible for the characteristic flavor and aroma of the fresh juices. It is possible to condense a portion of these volatile compounds with part of the water vapors and return this distillate to the concentrated juice, thereby intensifying the flavor and aroma of the syrup. M. K. Serailian of San Francisco has developed this method and applied it successfully on a small commercial scale. The writers have applied this method in the laboratory by use of the vacuum pan shown in figure 9. The distillate was collected and concentrated by redistillation and added to the syrup with notable intensification of flavor and aroma.

Concentration by Freezing.—Maple sap is often concentrated naturally by allowing some of the sap to freeze partially in buckets or tubs. Almost pure water separates in large ice crystals, leaving the unfrozen sap enriched in sugar. Cider is often partially concentrated by the same method.

Eudo Monti, an Italian, was one of the first to apply this principle industrially. One of his methods consists in freezing the juice to a mixture of ice crystals and syrup and then separating the ice and syrup by gravity in a tall, refrigerated, jacketed cylinder. In another method a metal cylinder filled with the freezing solution revolves in a tank of juice. Ice forms on the cylinder and is removed by scraping.

H. C. Gore* of the United States Department of Agriculture, in experiments at Hood River in 1914, adapted the concentration of apple juice by freezing to operations on a commercial scale. The juice was frozen to a mushy mixture of ice crystals and syrup in ice cans. The frozen juice was crushed and the ice and syrup were separated by centrifugal action in a perforated basket centrifuge of the type used in sugar factories. The syrup thus obtained was again frozen, then broken up in an ice crusher and centrifuged a second time.

In applying Gore's process in the Fruit Products Laboratory at the University of California, the juice was allowed to freeze at 10 to 15° F. for 24 to 36 hours in agate ware buckets. It was then centrifuged and allowed to freeze a second time at 0 to 5° F. It was centrifuged a second time. Two additional freezings and centrifugings were generally found necessary to concentrate the juice to 50° Balling. The centrifuge shown in figure 10 was used.

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* Gore, H. C., Apple Syrup and Concentrated Cider. U. S. D. A. Year Book, Separate No. 639, 1914.

Grape and apple juices gave excellent syrups by the freezing process. Orange and lemon juices yielded very satisfactory syrups when made to about 30° Balling by the addition of cane sugar before freezing. Unsweetened orange and lemon juices developed a disagreeable flavor during the concentration process. Berry juices tended to turn brown in color and lose much of their flavor, unless sweetened before concentration.

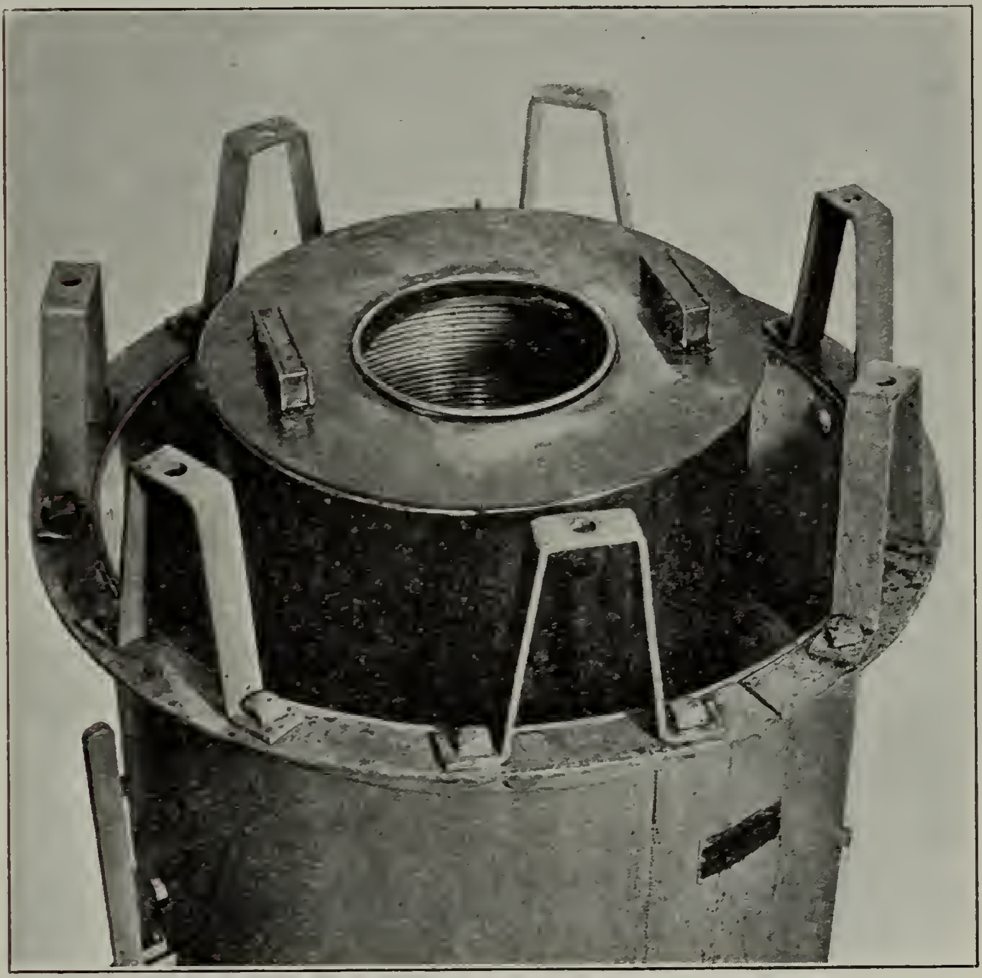

Fig. 10.—Basket centrifuge for separation of ice and syrup

In the Hawaiian Islands, pineapple syrup is made on a commercial scale by the freezing process. This syrup is of rich pineapple flavor and is excellent for bottlers' use.

Less energy is required for removal of water from fruit juice by freezing than by evaporation by application of heat. Approximately 80 calories of energy (heat) is required for freezing a gram of water and approximately 537 calories of heat is required for evaporation of a gram of water; that is, more than six times as much heat is required for the latter as for the former process. In practise, however, losses in energy during conversion of mechanical energy into heat energy by use of the ammonia cooling system and the extra cost of handling

the juice in the freezing process, probably more than counterbalance any saving in fuel by the freezing process. Fruit syrups made by the freezing process are undeniably superior in flavor to those produced by ordinary methods of vacuum concentration.

Grape syrups of excellent color and flavor were made in our experiments by blending Muscat syrup made by the freezing process, with red grape syrup prepared by vacuum concentration.

Concentration by the Spray Process.—The Merrill-Soule Company, well known producers of powdered milk, have prepared powdered fruit juices by the process in use for concentrating milk to a powder. Powdered lemon juice (sweetened before drying) and powdered orange juice from this company have been examined. The lemon juice powder made an excellent lemonade when dissolved in water. The orange juice powder was lacking in flavor.

An attempt was made in 1919 at Ferndale, in coöperation with C. E. Gray, President of the California Central Creameries, to concentrate grape juice to a powder in a large milk drying apparatus. The juice was sprayed in a large sheet metal chamber into a blast of heated air. Drying was almost instantaneous. It was found that the dehydrated juice melted at about 115° F. and that it absorbed water very rapidly from the air. With the apparatus used in the experiment it was impossible to obtain a powder. However, a small quantity of excellent syrup was obtained.

The writers believe that the spray drying process has great possibilities as a means of concentrating fruit juices, but realize that further experiments are necessary.

Syrups from Dried Fruits.—The preservation of fruit juices and syrups requires more space than equivalent quantities of the dried fruit. Experiments were made to determine the suitability of dried fruits for the preparation of syrups.

Dehydrated raspberries, loganberries, blackberries, and red wine grapes were soaked over night in enough water to return to the fruits the water removed in drying. The fruits were then pressed and the resulting juices made to 50° Balling by the addition of sugar. None of the syrups was satisfactory for the preparation of carbonated beverages. Further experiments using improved methods of dehydration are contemplated.

The general conclusion from the use of dehydrated fruits was that, although syrups of fair quality can be made from such material, the syrups are notably inferior to syrups made from the fresh fruits.

Seeded Muscat raisins were made into syrup by two different methods. In one method two gallons of water was placed on five pounds of raisins.* The mixture was heated to 165° F. and allowed to stand one hour. It was then pressed in a rack and cloth cider press. The juice thus obtained was placed on a second five pounds lot of raisins and treated as above. This procedure was repeated on three more lots of raisins; a total of five lots for the entire experiment. Two and one-fourth gallons of syrup was obtained. The Balling degrees of the various extracts corrected to 60° F. were:

First extraction	17° Balling
Second extraction	29° Balling
Third extraction	38° Balling
Fourth extraction	45° Balling
Fifth extraction	52° Balling

The syrup was filtered through pulp and tested for use in carbonated beverages. The raisin syrup alone gave a beverage of poor flavor, but when blended in the proportions of twelve parts of raisin syrup, two parts of orange syrup, and one part of lemon syrup, a syrup of excellent flavor was obtained.

The five lots of extracted raisins from the above experiment were treated in succession with the same amount of water as in the first experiment and the dilute syrup thus obtained was used to extract a sixth lot of raisins not previously extracted with water or syrup. The Balling degrees of the different extractions corrected to 60° F. were:

First extraction	10.0° Balling
Second extraction	18.0° Balling
Third extraction	21.5° Balling
Fourth extraction	34.0° Balling
Fifth extraction	42.0° Balling
Sixth extraction	49.0° Balling

The quality of this syrup was equal to that of the syrup from the first experiment.

A dilute water extract of the raisins was concentrated in a vacuum pan to 60° Balling. The syrup was reduced to 50° Balling by addition of the dilute raisin extract. The syrup had less Muscat raisin flavor than the syrup that was obtained by the repeated extraction process. It made a very pleasing beverage, however, when blended with orange and lemon syrups and diluted with carbonated water.

* Experiment performed by J. G. Brown.

Bottlers could prepare raisin syrup at their bottling establishments from the seeded Muscat raisins, or a central factory could manufacture it and distribute it, pasteurized, in lacquered cans, or glass bottles to bottlers.

Syrup prepared from figs in the same manner as that from raisins was blended with orange and lemon syrups and gave a satisfactory product which undoubtedly could be used successfully in beverages. It has a laxative property, which might be an advantage.

Blending of Syrups.—Our tests demonstrated that beverages made from certain blends of two or more fruit syrups were very popular. One blend, "Fruit Punch," was particularly well received. The syrup was first made by blending equal volumes of loganberry, orange, and lemon syrups of 50° Balling, and was prepared from the fresh juices by addition of sugar.

Later this blend of syrup was made by blending equal volumes of vacuum concentrated red grape syrup, vacuum concentrated orange syrup diluted with simple syrup, and lemon syrup made by addition of sugar to lemon juice. This syrup contained a larger proportion of fruit juice and required the addition of less sugar than the syrup in which the loganberries were used, yet it was quite as good.

"Raisinade" syrup, a blend of Muscat raisin, orange, and lemon syrups, has been described under Syrups from Dried Fruits; see page 547.

Equal volumes of pomegranate, pomelo (grape fruit), and orange syrups made a satisfactory blend. They were all made from fresh juice by adding sugar; the pomegranate syrup was 35° Balling, the others 65°.

Strawberry syrup and the beverages made from it fade and become brown. Blackberry syrup lacks distinctive flavor, but is of intense color. When one volume of blackberry syrup is blended with three volumes of strawberry syrup, a syrup of rich strawberry flavor and deep red color is obtained. The color does not fade rapidly, either in the syrup or in carbonated beverages made from it.

Numerous other blends of syrups such as red grape with strawberry and with raspberry, orange with pomegranate and apple, and apple with raisin were prepared and made into carbonated beverages. Many of these blends were very satisfactory.

The prospects of improving the quality of fountain and bottlers' syrups and of increasing the range of products through the blending of various fruit syrups are indeed promising.

PRESERVATION OF FRUIT SYRUPS

Almost all of the fruit syrups prepared in our experiments were of such low Balling degree, 45–65°, that they required treatment to prevent their spoiling.

Preservation by pasteurization in bottles and in cans, by the use of sodium benzoate, and by cold storage at 32° F. and at 0–15° F. were compared.

Cold Storage.—Syrups stored at 32° F. without pasteurization kept well during the first two months of storage, except a few samples which developed mold. Nearly all samples of syrup stored at 32° F. for more than six months became moldy or fermented. Similar results were obtained at 26° F. to 28° F. Syrups pasteurized in sealed containers, however, did not spoil and retained their flavor and color much more satisfactorily than pasteurized samples held at room temperature.

Storage at 0 to 15° F. resulted in partial freezing of the syrups and all growth of mold and yeast was prevented. It was found necessary to store the syrups in sealed containers in order to prevent absorption of a 'cold storage' flavor. Five gallon carboys and inside enameled cans were found satisfactory. The syrups increased considerably in volume in freezing storage and it was necessary to leave ample head space in the carboys and cans to prevent breakage.

Berries packed in barrels with an equal weight of sugar are successfully held in commercial cold storage warehouses at 18° F. Doubtless this temperature would also prevent spoiling of fruit syrups.

As a result of these experiments and observations it is recommended that fruit syrups intended to be held in cold storage be placed in inside enameled five gallon or one gallon cans and that the cans be sealed, and stored at not above 18° F. The canned frozen syrups may be delivered to bottlers and fountains directly from the cold storage warehouse. Such syrups should be used within four or five days, unless they are again placed in cold storage, e.g., in an ice chest, or pasteurized in sealed containers. In large cities, however, the bottler or soda fountain could obtain the frozen syrups as needed and in such quantities that they could be used before spoiling. Syrups packed in pint or quart cans might be delivered to grocers or other dealers and by such dealers in turn to individual families for home use.

The present rate for cold storage of frozen berries packed with sugar is 37½ cents for one hundred pounds for the first month and 12½ cents a month thereafter. This would correspond to about 4 cents and 1⅓ cents per gallon respectively for freezing storage of syrups.

The idle cold storage equipment of breweries is suitable for the bulk storage of fruit syrups.

Where freezing storage is available it is recommended in preference to all other methods of preserving fruit syrups.

Pasteurization.—Heating in sealed containers was found to be an effective method of preservation.

Non-carbonated syrups required heating to 175° F. for thirty minutes in quart bottles and for forty-five minutes in gallon bottles.

In tin containers, heating to 165° F. before sealing and keeping at this temperature for thirty minutes after sealing was sufficient.

In four and eight ounce jars sealed under vacuum only 150° F. for fifteen minutes was necessary.

Carbonated juices required only thirty minutes' heating at 150° F.

The causes of these differences are (1) that the removal of most of the oxygen in vacuum sealing and in sealing cans hot prevents the development and growth of molds that are not killed at the lower temperatures used. (2) The presence of carbon dioxide in the carbonated liquids has the same effect.

Syrups retained their color and flavor much better in glass than in tin. Red syrups in plain tin faded and acquired a bluish or purplish tint. In lacquered (inside enameled) cans the color deteriorated much less rapidly. In some instances the lacquer imparted a disagreeable flavor. Loganberry syrup, after pasteurization at 175° F. in gallon enamel lined cans and storage for six months at room temperature was still satisfactory in color and flavor for the preparation of carbonated beverages, although not so attractive in either respect as syrup from the same lot stored at 0 to 15° F. in various containers.

As a result of these experiments the writers recommend the use of glass containers and carbonated or vacuum sealing for red syrups. Cans are satisfactory for Muscat grape and other white grape syrup, though glass containers are more attractive and permit the user to inspect the syrup before purchase.

Chemical Preservatives.—Fruit syrups are generally preserved for the use of soda fountains and bottlers by the addition of one-tenth of one per cent of sodium benzoate.

Examination of a number of commercial syrups preserved in this manner showed that the preservative imparted a disagreeable 'burning' flavor to the syrup and in many cases a pronounced 'chemical' flavor resembling the flavor imparted by iodoform.

While the use of sodium benzoate is permitted by the Pure Food and Drug regulations of the Federal and state governments, the present tendency among food manufacturers in general is to substitute pasteurization or sterilization. Thus tomato catsup is no longer preserved by benzoate in up-to-date catsup factories. The public prefers food free from chemical preservatives.

Sulfurous acid is the only other chemical preservative permitted by law. Its use for preserving fruit syrups for bottlers' and fountain use is not feasible because of its injury to the flavor of the products when used in sufficient quantity to prevent spoiling. The use of salicylic acid in foods is prohibited by law.

The writers recommend preservation by pasteurization or cold storage and advise against the use of chemical preservatives in fruit syrups.

USES FOR FRUIT SYRUPS

The suitability of various fruit syrups for the preparation of carbonated beverages, soda fountain drinks, frozen desserts, gelatin desserts, confections, jellies, and homemade fruit punch was studied.

In Soda Fountains.—The highly flavored syrups were found excellent for preparing ice cream sodas, carbonated mixed drinks, and as dressing for ice cream. One objection made to the syrups was their liability to mold or ferment after several days standing in the open bottle. This difficulty may be overcome by adding sugar to increase the balling to about 65–70° F. Sodium benzoate should not be used.

In Carbonated Bottled Beverages.—Most of the syrups produced in our experiments were found suitable for the preparation of carbonated bottled drinks. For details of these experiments see pages 553 to 562.

In the Home.—The types of syrup which proved most satisfactory such as the berry, orange, and fruit punch syrups, were bottled and pasteurized in eight ounce bottles. These were used in various ways by many housewives of Oakland and Berkeley.

Fruit punch was prepared in the home in many instances by simply diluting the syrups with water and crushed ice, or with carbonated syphon water. In other cases, the syrups were mixed with fresh lemon or orange juice, or with bottled grape juice, water, and sugar. All the reports received upon the use of the syrups in this manner were very favorable.

When added to uncolored and unflavored gelatin and water, very pleasing desserts were made. The gelatin, first dissolved in hot water, was mixed with enough syrup to obtain a pleasing flavor and color. The berry syrups proved most popular for this purpose.

The syrups greatly improved the flavor of fruit cocktails or 'starters' (i.e., sliced fresh or canned fruits, such as mixtures of peaches, pears, pineapple, banana, grape fruit etc.). They were also found suitable for use in the preparation of pudding sauces. Other similar uses suggest themselves. The past year's experience leads the writers to believe that the sale of fruit syrups for household use affords as important an outlet as the bottling industry and soda fountain trade.

For the household trade the small containers, e.g., eight ounce bottles, were preferred, although there was some demand for syrup in larger quantities for use in preparing fruit punch to serve at dances and other social gatherings.

In Frozen Desserts.—Ice cream and water ices were prepared from the syrups experimentally in the laboratory by S. A. Bjarnason, a former graduate student, and by others. The results were in all cases very satisfactory. Berry syrups and Muscat raisin syrup blended well with cream, gelatin, and sugar in the preparation of ice cream.

Although these experiments were not extensive they were sufficiently conclusive to warrant recommendation of the use of these syrups in ice cream and water ices in ice cream factories and in the home.

In Confections.—The syrups were made into centers for chocolate dipping by combining them with pectin and sugar and concentrating to a boiling point of 225° F. Syrups rich in pectin (loganberry, apple, and lemon) required the addition of less pectin than others. In general, however, the addition of sufficient pectin or pectin syrup to give a finished product containing about one and ont-half per cent pectin was found desirable. Satisfactory results were obtained by combining one and one-half ounces of dry powdered pectin, two pints of berry syrup, two pounds of sugar, and two pints of water. The pectin and sugar were first dissolved in the water, then mixed with the syrup and the whole concentrated to a boiling point of 225° F. The hot liquid was placed to a depth of about one half-inch in oiled pans to cool and solidify. It was then cut in rectangular pieces and dipped in chocolate. The candy was produced on a semi-commercial scale and was well received.

Concentrated berry syrups were used successfully by a large candy factory for flavoring cream fondant used as centers for chocolate cream candies. The genuine fresh berry syrups were found

markedly superior to the artificially colored and flavored imitation berry syrups used for this purpose.

In Jellies.—The syrups were used successfully for the preparation of jellies. In most cases it was found necessary to combine them with either pectin or fruit juices rich in pectin. Grape syrups, berry syrups and pomegranate syrup gave excellent jellies when prepared in the above manner.

While suitable for the home preparation of jellies, it is probable that the cost would be too great for commercial jelly manufacturers.

USE OF FRUIT SYRUPS IN CARBONATED BEVERAGES

Investigation has proved that a very small percentage of the bottled carbonated beverages now on the market contain fruit juice. A very large quantity of imitation orange and strawberry drinks is bottled in carbonated form. Recently imitation grape syrup has been used extensively in preparing carbonated bottled drinks.

The principal object of the investigations reported in this bulletin has been to determine the practicability of using real fruit syrups in carbonated bottled beverages.

Carbonating and Bottling Equipment at University.—A small high pressure carbonating machine was installed in the fruit products laboratory in November, 1921. This machine consists of a tin lined heavy walled steel cylindrical tank fitted with a stirrer and small force pump. The carbonating chamber holds about five gallons of water. Water can be forced by the pump into the cylinder against pressure of carbon dioxide gas.

Carbon dioxide gas is admitted to this clyinder from a cylinder of the liquefied gas through a regulating valve by means of which any desired pressure of gas can be maintained in the carbonator. At the same time water or juice is pumped and sprayed under pressure into the carbonating chamber and is mixed with the gas by the stirring device. The pump and stirrer are operated by a small electric motor which is controlled by an automatic switch. The switch automatically cuts off the current to the motor when the carbonating chamber has been filled with liquid.

This small crabonator has a capacity of about twenty gallons of water or juice an hour. It has given excellent service.

A foot power crown soda bottling and capping machine was used in conjunction with the carbonator. This machine is equipped with an adjustable syrup measuring device, by means of which the desired volume of syrup may be measured into each bottle, and with a carbonated water delivery head, by means of which the bottles may be filled with carbonated water or juice directly from the carbonating chamber.

It was found possible for one man to carbonate and crown six hundred bottles of beverage in eight hours.

Various carbonating and bottling machines are shown in figures 11, 12, and 13.

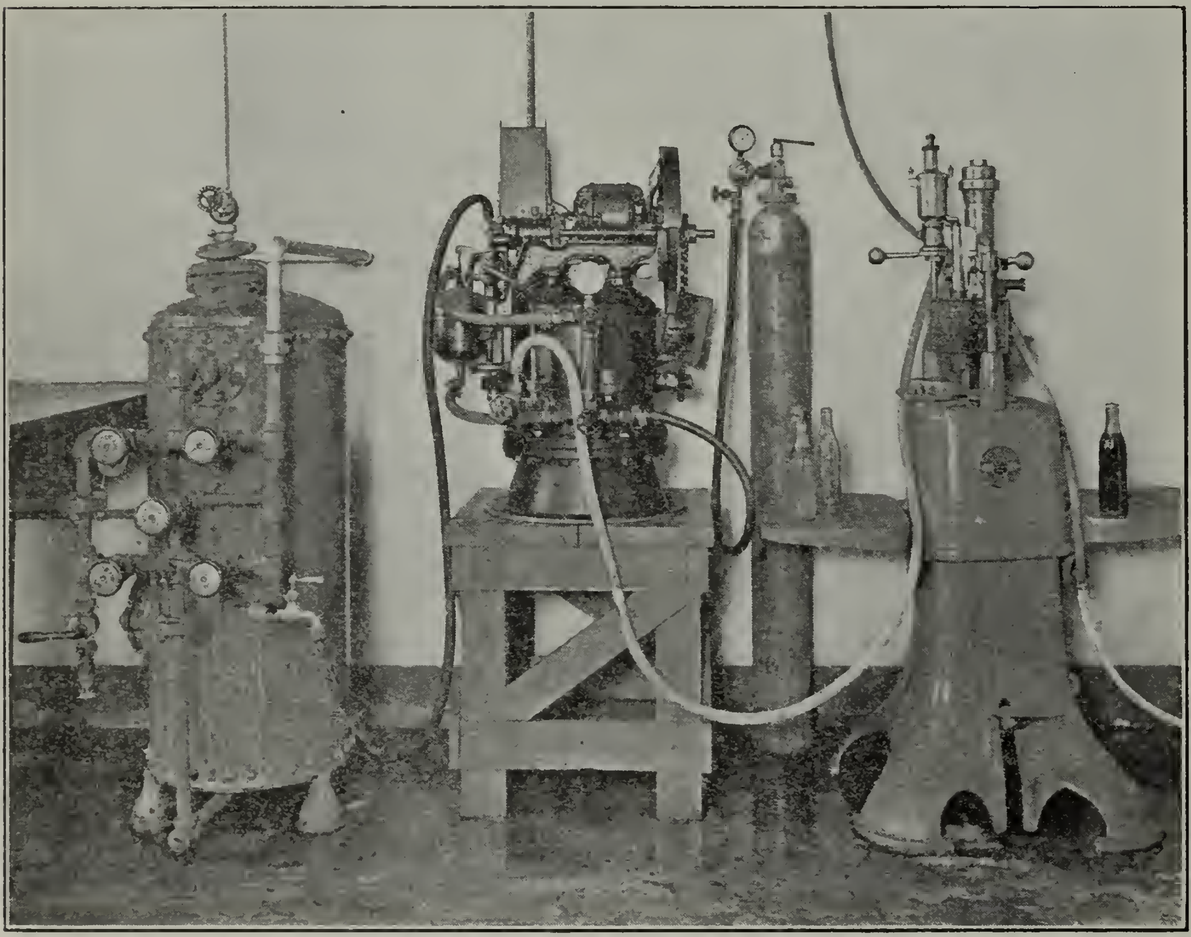

Fig. 11.—Water softening, carbonating and bottling equipment in the Fruit Products Laboratory.

Carbonating and Crowning.—Seven and eight ounce soda water bottles were used in our bottling experiments. Most of the syrups were used at the rate of one and one-half fluid ounces (about forty-five cubic centimeters) to a bottle, the bottling machine being adjusted to deliver this amount of syrup to each bottle. Carbonated water was added to fill each bottle within about one and one-fourth inches of the top and the bottle was immediately sealed with a crown cap applied by the foot power crown capper.

Carbonated beverages were made from several varieties of fruit syrups with water charged at 10, 20, 30, 40, 50, and 60 pounds pressure of carbon dioxide; the water being carbonated at about 50° F. Most of the persons who sampled the different lots preferred those carbonated at 30 or 40 pounds.

The gas pressure indicated by the gauge on the carbonator during the carbonating of water used in preparing beverages for sale was approximately forty pounds. This corresponds to a pressure of about fifteen pounds to the square inch in the bottle after sealing. This pressure of gas was preferred by most consumers. At higher pressures much of the beverage was often lost by frothing when the bottles were opened and the juice was too highly charged to make a pleasing beverage. At much lower pressures some of the beverages were rather 'flat' in taste and were not sufficiently effervescent.

The water in our experiments was used at a temperature of about 50° F. If carbonated at temperatures above 50° F., it was necessary to use higher pressures in order to attain the same pressure of gas in the bottle at room temperature because of the decrease in solubility of the gas in water with increase in temperature. At temperatures lower than 50° F., lower gas pressure should be used to compensate for the increase in solubility of carbon dioxide with decrease in temperature.

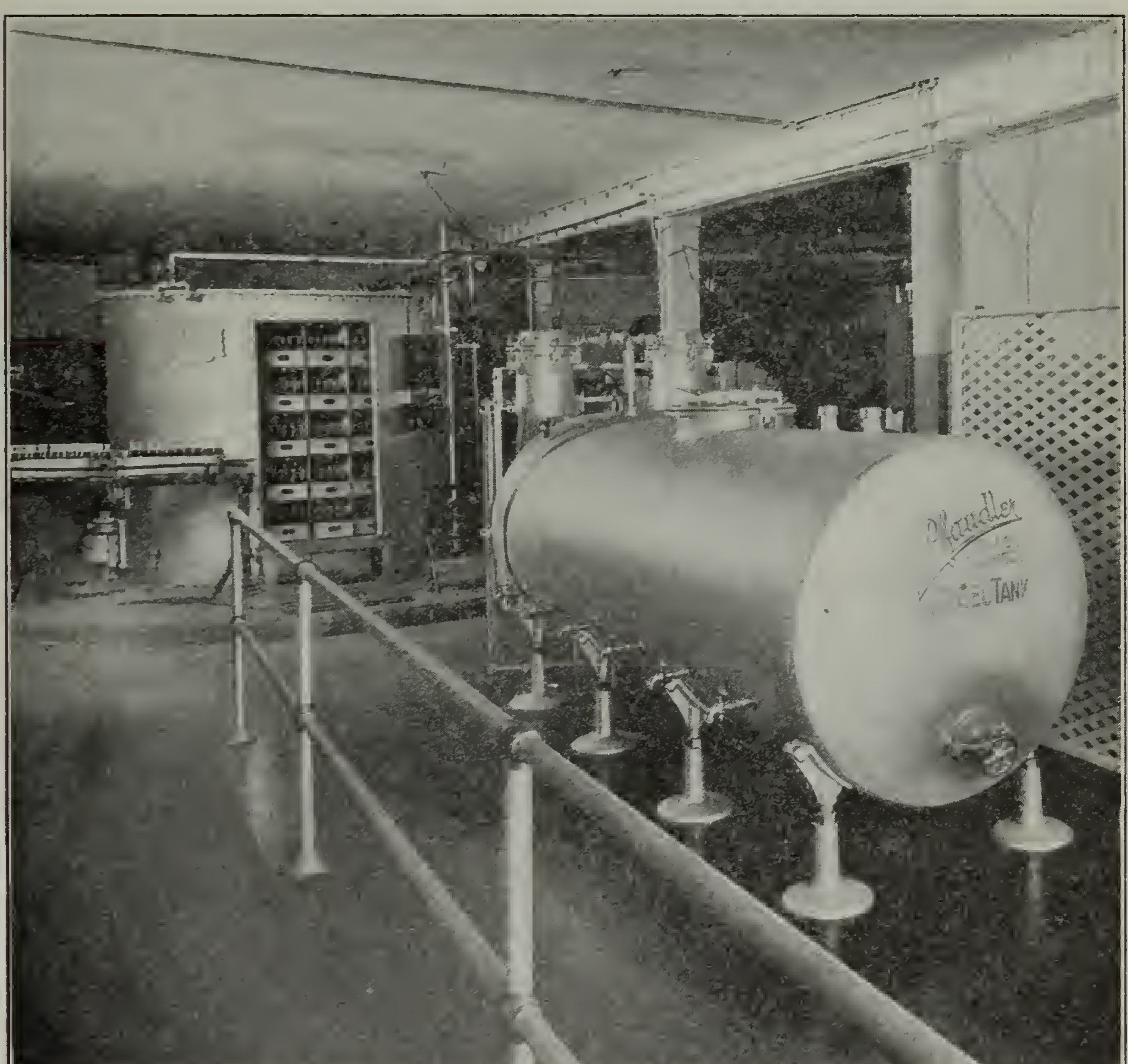

Fig. 12.—Carbonated water storage tank and continuous bottle pasteurizer. Henry Brown Company, Glendale.

Many producers of carbonated beverages use the low pressure system of carbonating. The syrup and water are mixed in a large tank at a temperature at or near the freezing point of water, 32° F. At this low temperature the solubility of the carbon dioxide is much greater than at room temperature. Glass lined steel tanks are generally used for carbonating liquids at low pressure. This method greatly simplifies bottling equipment and operations and gives a product of more uniform character and gas pressure. Liquids carbonated and bottled by the low pressure system do not foam so excessively during bottling as those carbonated at high pressure at room temperature.

Small bottling works, for the most part, still use the high pressure carbonating system and automatic filling and crowning machines. Bottles vary greatly in size and owing to the fact that the same volume of syrup is measured into each bottle, regardless of its size, there is considerable variation in the composition of the beverage in different bottles. High pressure carbonating systems do not require refrigerating facilities and in general are less costly to install than the low pressure system.

Figures 11, 12, and 13 show typical carbonating and bottling equipment.

Comparison of Waters Used in Carbonated Beverages.—Bottlers use several types of water in carbonated beverages. The more progressive use distilled water; some use filtered water and others plain tap water. Tap water varies greatly in character according to the locality and the season.

In our experiments, distilled water, tap water, and water softened and filtered by use of a Borromite water softener and filter were compared. In experiments with filtered orange syrup, the tap water caused a flocculent deposit in the carbonated beverage, while the samples made with distilled water, and with water from the Borromite filter remained clear. With other syrups the difference was similar, but not so pronounced, although more deposit formed in the bottles containing tap water.

In the water softener a compound of sodium is used which precipitates calcium and magnesium salts. The salts of these metals are the principal cause of hardness of water, and probably one of the causes of cloudiness and precipitates in carbonated beverages. Sodium salts dissolve in the water and replace the precipitated magnesium and calcium salts.

As a result of these experiments and of observations in bottling plants, it is recommended that distilled water be used in preference to tap water for bottled carbonated beverages.

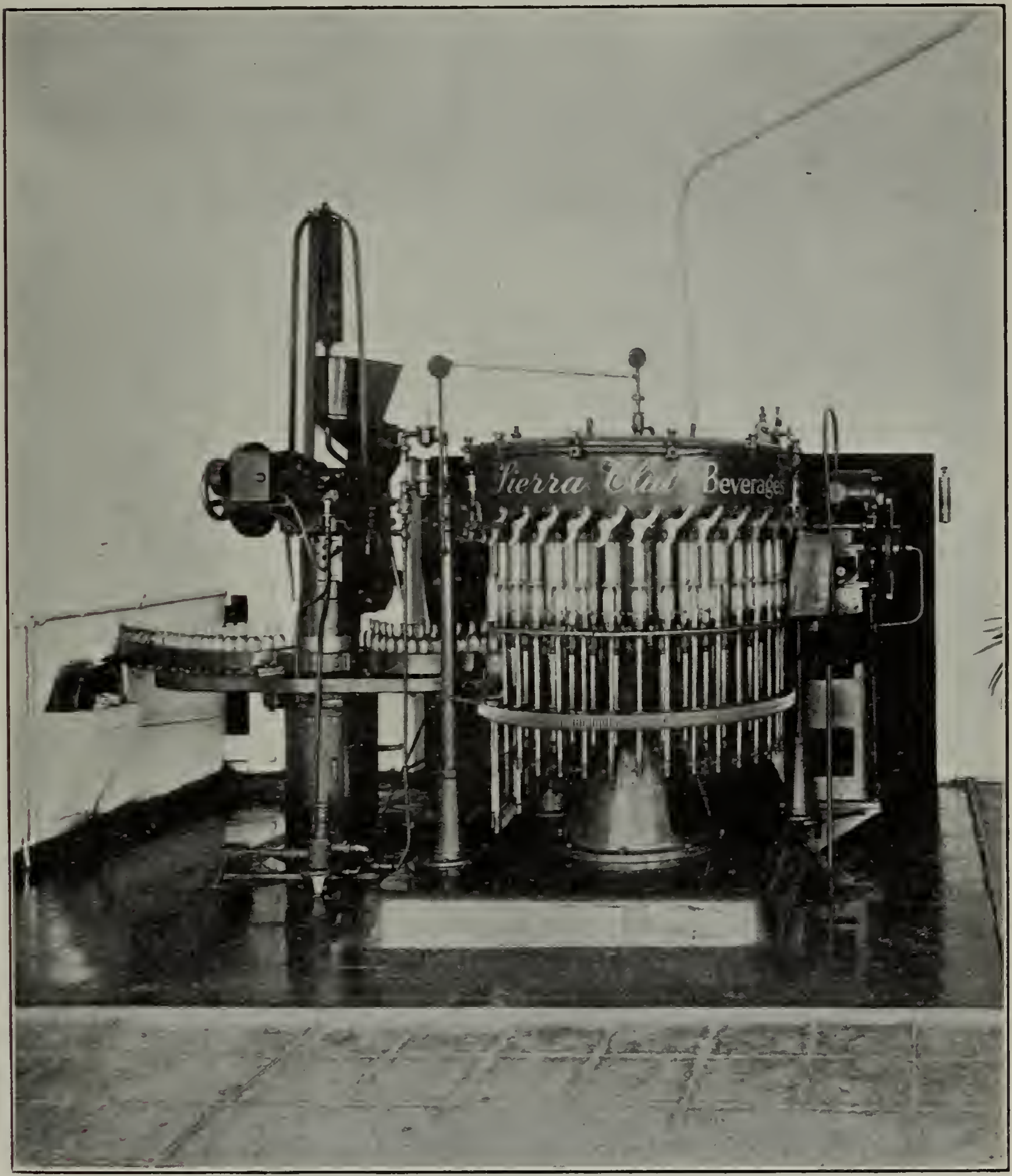

Fig. 13.—Low pressure bottling machine and bottle sealer. Henry Brown Company, Glendale.

Pasteurization Experiments.—Carbonated fruit beverages soon undergo fermentation unless pasteurized. Carbon dioxide prevents the growth of mold, a fact which greatly simplifies pasteurization. Our experiments proved that a temperature of 150° F. destroyed all yeast cells in carbonated juice. In non-carbonated beverages mold spores frequently develop and cause spoiling even when pasteurized at 175°.

A large number of samples of bottled cabonated fruit beverages were inoculated with actively fermenting yeast cultures, spore bearing bacteria, and the spores of several varieties of molds, and pasteurized at various temperatures for various lengths of time. The numbers of these microörganisms present before and after pasteurization were determined and samples were incubated at about 80° to 85° F. to hasten spoiling of insufficiently pasteurized samples. One dozen bottles were used for each test.

The following observations were made. Samples inoculated very heavily with active yeast did not ferment after being pasteurized at 140° F. for forty minutes, nor at 150° F. for thirty minutes. There was no appreciable difference in the flavor of beverages pasteurized at these two temperatures. Some mold spores survived 170° F. for thirty minutes but were unable to develop in the carbonated samples. In non-carbonated checks, mold developed in samples heated to 170° F. or lower temperatures. Heating to 175° F. for thirty minutes prevented mold growth in non-carbonated samples. Spore bearing bacteria (*Bacillus subtilis,* and a spore bearing bacillus from spoiled canned vegetables) survived all temperatures used in our experiments, 120° to 212° F., but did not increase in numbers in the beverages and did not cause spoiling. The beverages were evidently wholly unsuited to their growth.

From these experiments it was decided that a pasteurization of 150° F. for thirty minutes or of 140° F. for forty minutes should be recommended for carbonated fruit beverages. A pasteurization of 175° F. for thirty minutes appears to be necessary for non-carbonated fruit juices and syrups in order to prevent mold growth.

Heat Penetration.—The rate of heat penetration in bottled carbonated beverages was determined several times. The filled bottles were placed in a rectangular metal tank holding about one hundred and fifty bottles. The bottles were placed in a horizontal position and the tank was filled with water to completely cover the bottles. Thermometers were inserted in two bottles with the bulbs near the center of the bottles. The water was heated by a perforated steam pipe to the pasteurizing temperature. Temperature readings of the thermometers in the bottles and of a thermometer immersed in the water of the pasteurizing tank were made frequently.

After thirty minutes at the pasteurizing temperature, cold water was added rapidly to displace the heated water and readings were taken as the bottles were cooled in this water. Table 2 gives the results of one such test.

In this test the pasteurizer reached the pasteurizing temperature in seven minutes. The centers of the bottles reached 144° F. in twenty minutes and 150° F. only at the end of thirty-seven minutes. Figure 14 shows graphically the rates of heat penetration.

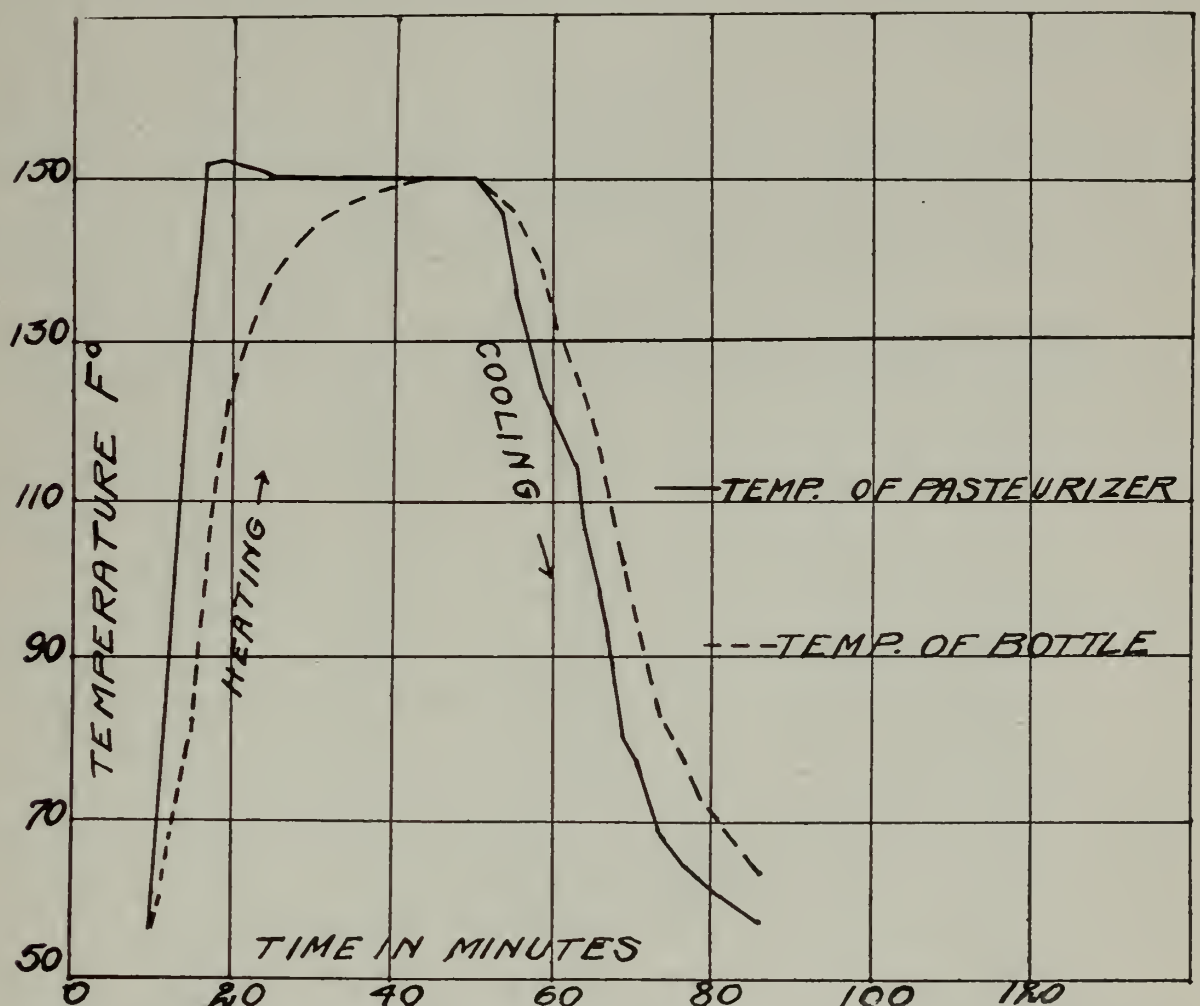

Fig. 14.—Curves showing rates of heat penetration and cooling of bottled beverages.

Commercial Pasteurization of Bottled Beverages.—Most carbonated beverages now on the market are not pasteurized. Pasteurization does not appear to be necessary for synthetic (artificial) beverages. Cereal beverages and those in which some fruit juice is used are pasteurized, these beverages being produced in most cases in large, well equipped bottling plants.

Pasteurization increases the cost and on this account has not been adopted generally by the small scale bottlers. It is possible, however, to build relatively inexpensive, yet efficient pasteurizers and the cost of pasteurization need not be high.

A very simple pasteurizer in use in a fruit juice factory in Contra Costa County consists of a redwood vat about ten feet long, about three feet wide and about two and one-half feet deep. Several turns

of perforated steam pipe in the bottom of the tank serve for heating the water used in pasteurizing. A wooden grating rests on the coils and prevents direct contact of the bottles with the steam jets. The bottles are stacked in the pasteurizer in perforated sheet metal crates and are covered with water. Similar pasteurizers are in use in other juice factories.

TABLE 2

RATES OF HEAT PENETRATION AND COOLING OF EIGHT OUNCE BOTTLES OF FRUIT BEVERAGE

Time in Minutes	Temperature °F. of Pasteurizer	Temperature °F. of Bottle. Average of two bottles
0	56	58
5	134	82
7	152	102
10	152	122
15	150	137
20	150	144
25	150	147
30	150	149
35	150	149
37	150	150
Cooling after Pasteurizing		
0	150	150
3	146	148
5	136	146
8	124	140
10	122	131
13	106	124
15	98	118
18	80	102
20	76	95
23	68	83
26	64	77
28	62	72
30	60	70
35	57	63

In large bottling establishments continuous pasterizers of various designs in which the temperatue is automatically regulated are used. In most of these the bottles are heated gradually as they pass through sprays or tanks of water of gradually increasing temperature until

the pasteurizing temperature is reached. After pasteurization the bottles pass through water of progressively decreasing temperature. Figure 12 illustrates a pasteurizer of this kind.

A homemade continuous pasteurizer was recently observed in operation. It consisted of a wooden tank about seventy-five feet long, about three feet wide, and about two feet deep. It was divided into several sections and was filled with water heated by open steam coils. The bottles of juice were placed in perforated sheet metal boxes. These were carried progressively through the water in the several sections of the pasteurizer. The different sections were maintained at different temperatures so that the bottles were subjected to gradually increasing temperatures.

A very satisfactory automatic pasteurizer holding seventy-two dozen bottles at a charge can be bought and installed for $325. A ten horse power boiler to operate it can be obtained for about $250. The capacity of this pasteurizer is about five thousand bottles in eight hours.

Keeping Quality of Fruit Beverages.—Carbonated orange and lemon beverages in bottles were found to deteriorate rapidly in quality after six to eight weeks' storage at room temperatures. They must therefore be consumed within two months after bottling.

Carbonated bottled fruit punch made from loganberry or red grape syrup, combined with orange and lemon syrups, retained its flavor and color very satisfactorily for six months. It seems a more desirable beverage than either the orange or lemon beverages alone.

"Muscat blend" bottled and carbonated has retained its color and flavor for at least fifteen months. Apparently it is as stable as ordinary bottled grape juice. This blend was made from equal volumes of vacuum concentrated Muscat and red wine grape syrups. No sugar was used in its preparation.

A strawberry beverage after about three months' storage became brown in color, but one of strawberry and blackberry has retained both color and flavor very well for the six months that it has been stored.

Loganberry and raspberry beverages have retained their color and flavor very satisfactorily for six months.

Pomegranate carbonated beverages deteriorated in flavor and color during storage when highly diluted, but beverages containing a large percentage of the juice have retained their quality very well.

Samples of all varieties of bottled carbonated beverages prepared in our experiments are still under observation to determine changes in flavor and color on prolonged storage.

Use of Fruit Syrups by Commercial Bottlers.—A well known bottling establishment which distributes bottled carbonated beverages throughout the Pacific Coast states is now producing several bottled carbonated fruit beverages from citrus fruit, loganberry, and pineapple syrups. An Oakland bottling company is now marketing loganberry and pineapple bottled carbonated beverages. A Salem, Oregon fruit juice company has for several years successfully marketed large quantities of a bottled, carbonated loganberry beverage. In addition there are many 'near fruit' carbonated beverages on the market made of some fruit juice, sugar, artificial color and flavor.

Samples of syrups were distributed to several bottlers in the San Francisco Bay district for experimental bottling purposes. With one exception all reports on the use of the syrups were favorable. The cause of the unfavorable report was the fermentation of the syrup before it was used, as a result of a leaky syrup container.

Bottlers have expressed themselves in favor of the fruit beverages but have hesitated to undertake their manufacture because the existing 'cut-throat' methods of competition make the higher price of fruit syrups and the necessity of pasteurizing a serious handicap. If, however, the beverages could be sold at ten cents a bottle, retail, bottlers have stated that it is commercially possible to produce carbonated fruit beverages with a profit to all concerned. Our experience proves that this price will be paid readily by a large proportion of those who use carbonated beverages. The writers therefore sincerely believe that the production of real fruit carbonated bottled beverages is commercially feasible.

SEMI-COMMERCIAL PRODUCTION AND SALE

During the past fifteen months approximately five thousand bottles of carbonated fruit beverages were prepared and sold by the Fruit Products Laboratory. Approximately five hundred bottles of fruit syrups have been sold during the past six months.

Our distribution has been made through a Berkeley grocery store and by direct sale at the Fruit Products Laboratory, for the past eight months. For a period of two months the products were on sale in an Oakland market.

Syrups.—As an experiment, a few eight ounce bottles each of loganberry, strawberry, orange, raspberry, fruit punch, and blackberry syrups were placed on sale in the East Bay Market. The syrups were those used regularly in the preparation of the bottled carbonated beverages and were pasteurized at 175° F. for thirty minutes.

Approximately one hundred twenty bottles were sold during the six days on which the syrups were on sale. Many of the sales represented repeat orders, usually cases in which a customer purchased one bottle for trial and later returned for six bottles or more. Reports from customers were in all cases favorable. The syrups were used in most cases for homemade punch for childrens' parties, etc., but some of the syrups were used with apple pectin for jelly, with gelatin for gelatin desserts, and in frozen desserts. Loganberry, orange, and fruit punch were the most popular syrups. Approximately twice as much loganberry as any other single syrup was sold. Its intensely red color, brilliantly clear appearance, and pronounced flavor made it popular.

Sales of this syrup at the University have also been very satisfactory. Much less 'sales effort' has been expended on the syrups than on the beverages. Because of the numerous repeat orders for the syrups the writers believe that their manufacture affords a very promising field for commercial development; one at least as attractive as the production of bottled carbonated fruit beverages.

Bottled Beverages.—On Picnic Day, April 22, 1922, at the University Farm five hundred bottles of assorted carbonated beverages (orange not included) were placed on sale by the students. The entire lot was sold in less than three hours. There were many repeat orders and several hundred would-be purchasers could not be served. Comment in all cases was favorable. Loganberry, Muscat grape blend, raspberry, and fruit punch were most popular. Blackberry and pomegranate beverages lacked flavor. No one objected to the price of ten cents a bottle. On April 28, 1923, similar results were obtained.

The beverages have been on sale at the Faculty Club on the University campus, where a steady demand has developed. The beverages are used chiefly at evening meetings of various organizations at the club and for sale during the day at the club's cigar stand.

A steady demand for the beverages for family use has developed at Sill's Grocery in Berkeley. Purchases are frequently made in lots of one dozen bottles. The sale at this store was started with a one day's demonstration. No effort has been made to artificially stimulate the demand since the first day's sale. Continuation of satisfactory sales therefore represents a real demand for the products. Loganberry, orange, and raspberry beverages have been most popular at this store.

In spite of the 'cash and carry' feature of the sales made in the Fruit Products Laboratory, sales to the campus public have been satisfactory and many repeat orders have been received.

During the winter months the demand has been limited.

Wider distribution of the beverages through groceries, cigar stands, soda fountains, and markets will be attempted during the coming summer. Attempts will also be made to encourage the bottling of fruit beverages by commercial concerns.

Carbonated Beverages in Bulk.—At the request of one of the senior students in Agriculture, five gallons of carbonated fruit punch was prepared for a fraternity dance. It was enthusiastically received and the fame of the punch soon spread to other student organizations. Frequent sales of the carbonated punch in bulk are now made and the demand for it is increasing.

The carbonated punch has been prepared by mixing heavily carbonated water, chilled to slightly above 32° F. before carbonating, with a blend of red grape, or loganberry, orange, and lemon syrups. The punch is immediately placed in cold storage after carbonating and delivered cold to the customer.

The punch has been prepared in fifty gallon lots in barrels for functions of the College of Agriculture.

The writers believe that carbonating fruit punches will greatly increase their popularity and suggest this new method to soda fountains for trial.

The University will not remain in the business of semi-commercial production of fruit syrups, bottled beverages, and carbonated punch indefinitely, but merely long enough to induce commercial agencies to give the new products a fair trial.

COST OF PRODUCTION OF FRUIT SYRUPS AND CARBONATED BEVERAGES

The cost of producing various carbonated fruit beverages in the Fruit Products Laboratory is summarized in tables 3 and 4. The fruit was purchased in many cases in the wholesale fruit markets. *Oranges and lemons were furnished without cost to the University by the Exchange Orange Products Company of San Dimas and the Exchange Lemon Products Company of Corona. Grapes were obtained from the Viticulture Division at the University Farm, Davis, at prices prevailing at the time of harvest.

* The writers wish to express their appreciation particularly to Messrs. Wilson, Cassell, May, and House, of these companies, for fruit furnished for our experiments.

Bottlers usually make a charge to the customer for bottles and cases. In some instances this is one dollar and fifty cents per case of two dozen bottles, or at the rate of approximately six cents per bottle. This charge is refunded on return of the cases and bottles. In table 4 the last column represents the net cost to the bottler who prepares his own syrups.

It should be possible to sell all of these beverages at ten cents per bottle retail, provided the usual deposit for bottles and cases is charged.

TABLE 3

COST OF FRUIT SYRUPS

Fruit	Cost of one ton	Syrup Cost of One Gallon				Total
		Fruit	Sugar	Power and Labor	Pasteurizing and Container	
Apple	$15.00	$ .50	0	.25	.20	$1.00
Blackberry	143.00	.56	.34	.15	.20	1.25
Red Grape	50.00	.90	0	.25	.20	1.35
Muscat Grape	50.00	.63	0	.25	.20	1.08
Lemon	20.00	.40	.36	.15	.20	.81
Loganberry	143.00	.70	.30	.15	.20	1.35
Orange	20.00	.10	.36	.15	.20	.81
Pomegranate	20.00	.14	.12	.20	.20	.66
Raspberry	333.00	1.26	.34	.15	.20	1.95
Strawberry	205.00	.84	.36	.15	.20	1.55

TABLE 4

COST OF FRUIT BEVERAGES

Kind	Beverage Cost of One 8-ounce Bottle in Cents						Total Exclusive of Bottle
	Syrup	Labor	Bottle	Pasteurizing	Label	Total with Bottle	
Apple	1.25c	.46c	2.5c	.5c	.1c	4.81c	2.31c
Blackberry	1.56	.46	2.5	.5	.1	5.12	2.62
Red Grape	1.69	.46	2.5	.5	.1	5.25	2.75
Muscat Grape	1.35	.46	2.5	.5	.1	4.91	2.41
Lemon	1.01	.46	2.5	.5	.1	4.57	2.07
Loganberry	1.69	.46	2.5	.5	.1	5.25	2.75
Orange	1.01	.46	2.5	.5	.1	4.57	2.07
Pomegranate	.83	.46	2.5	.5	.1	4.39	2.89
Raspberry	2.44	.46	2.5	.5	.1	6.00	3.50
Strawberry	1.94	.46	2.5	.5	.1	5.40	2.90

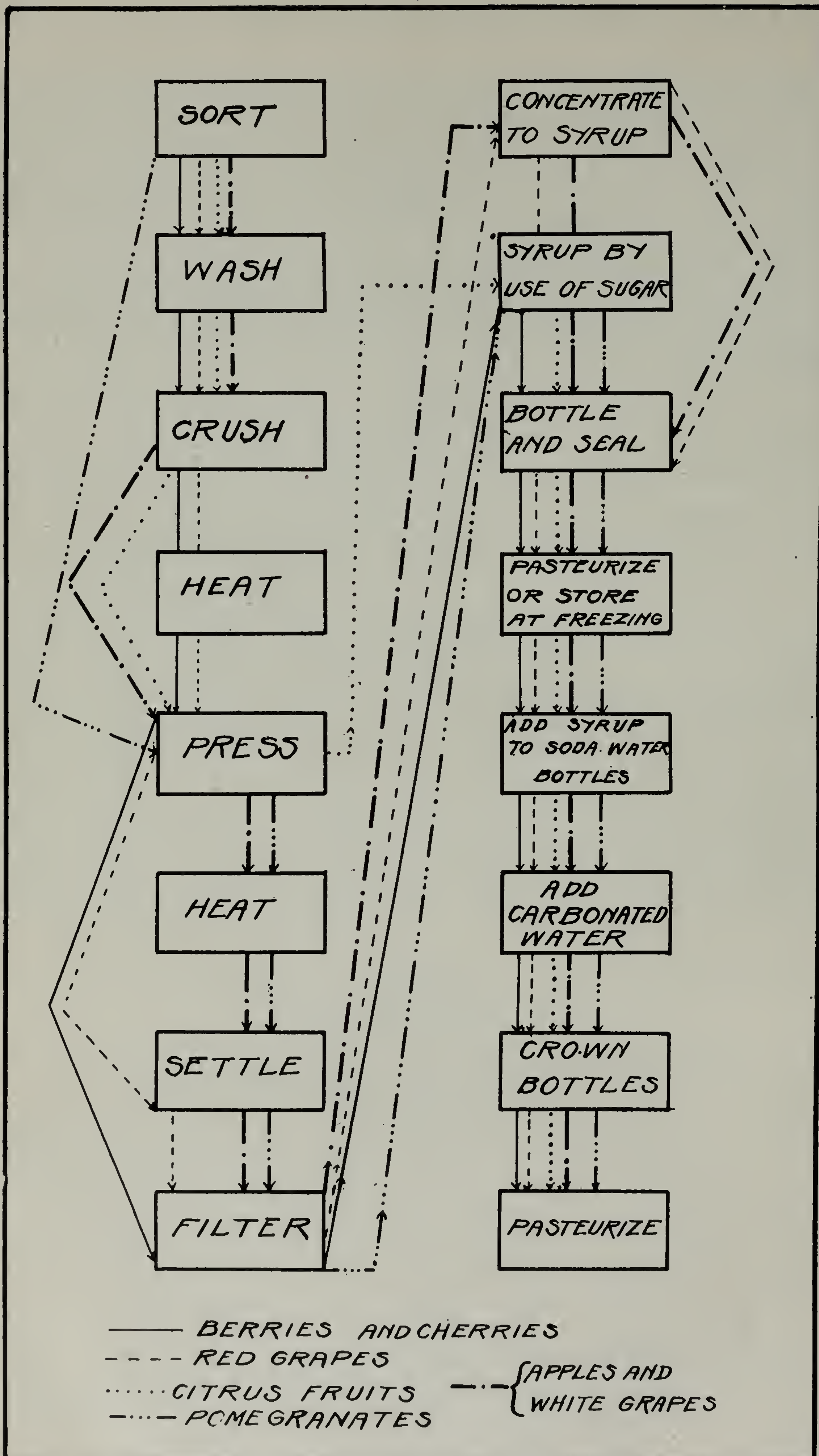

Fig. 15.—Outline of processes of preparing carbonated beverages from various fruits.

SUMMARY AND CONCLUSIONS

1. Most of the so-called fruit beverages now on the market contain little or no fruit juice.

2. Our experiments have demonstrated that excellent syrups and carbonated beverages may be made from loganberries, raspberries, oranges, lemons, and apples, and from blends of strawberries with blackberries, of Muscat with red wine grapes, of raisins with oranges and lemons, and of loganberries, red grapes or pomegranates with oranges and lemons.

3. Sugar was used in the preparation of all syrups except those made from grapes and apples.

4. Concentration by freezing and in a glass lined vacuum pan were both satisfactory methods of concentrating grape, apple, and citrus fruit juices.

5. Syrups were preserved satisfactorily by pasteurizing in glass at 175° F. for thirty minutes, or by storage at 0 to 15° F. in sealed containers without pasteurization. Glass containers were better than enamel lined tin containers for pasteurized syrups.

Preservatives imparted a disagreeable flavor and their use is not recommended.

6. The syrups were found excellent for the preparation of carbonated bottled beverages, for soda fountain use, the preparation of centers for candies and for home use in the preparation of punch, gelatin desserts, sauces, jellies, etc.

7. By the use of a small carbonating and bottling outfit, approximately five thousand bottles of carbonated fruit beverages were prepared and sold. Approximately one thousand bottles of various beverages were prepared experimentally and distributed to classes, visitors, and others for expression of opinion. Comments were generally favorable. A retail price of ten cents per bottle was willingly paid.

8. Loganberry, grape, strawberry-blackberry blend, apple, raspberry, and fruit punch bottled carbonated beverages have retained their flavor and color satisfactorily for from six to fifteen months. Orange, lemon, and strawberry deteriorated markedly in quality after two months' storage.

9. Pasteurizing at 150° F. for thirty minutes destroyed yeasts and prevented spoiling of carbonated fruit beverages heavily inoculated with yeast, mold, and bacteria. Heat resistant molds and bacteria were not killed by this treatment, but the carbon dioxide gas prevented their development.

10. Many commercial bottlers possess all necessary equipment for preparing carbonated beverages from fruit syrups. Some bottlers do not possess pasteurizing equipment, but this equipment can be built or purchased at moderate cost.

11. As a result of the investigations reported in this bulletin the writers are convinced that carbonated fruit beverages can be made and sold at retail for ten cents a bottle with a profit to all concerned. Our semi-commercial manufacture and sales have demonstrated that a market exists for them. A good demand for the syrups for home use was found. The writers recommend that the syrups be prepared in centrally located factories and distributed in pasteurized form or under refrigeration to bottlers, soda fountains, and grocers.

12. A large proportion of the surplus and cull fruits of California might be utilized to advantage in the preparation of fruit syrups and carbonated beverages.

Recommended processes of manufacture are shown graphically in figure 15.

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